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SHORE EROSION ON SANDUSKY BAY

PAUL R. SHAFFER

Department of Geology, University of Illinois,
Urbana, Ill.

The south shore of Sandusky Bay is undergoing severe erosion as a result of wave attack, and represents but one of a large number of badly eroded places along the south shore of Maumee Bay, Sandusky Bay, and Lake Erie (Fig. 1).

The geology of the area was studied as a co-operative project of the Geological Survey of Ohio and the Lake Erie Division of the Ohio Department of Public Works. The field work was done during August of 1946. The area, approximately 2 miles long, embracing the most southerly portions of Sandusky Bay has been designated Critical Area 34 by the Lake Erie Division of the Ohio Department of Public Works.

The area studied extends from the western boundary of section 5, Townsend Township, Sandusky County, Ohio, across section 4 of the same township. The eastern limit of the area lies approximately 2200 feet in a northeasterly direction from the western point of the wedge-shaped projection of the western border of Erie County, Ohio. The area lies in the Lake Plain section of northern Ohio, the general level of the surface along the shore of the bay being 580 feet above sea level (U. S. G. S. datum). The surface of the Lake Plain section rises very gradually southward at the rate of 8–10 feet per mile.

Critical Area 34 is drained by several ditches which flow northward into Sandusky Bay.

BED ROCK

The area is underlain by the Tymochtee shaly dolomite member of the upper Silurian, Bass Island formation (Carman, 1927, p. 488). The Tymochtee does not outcrop in the area and is overlain by glacial till and lacustrine clay. The owner of a 6-inch water well completed in the summer of 1946 at Perry's Harbor, White's landing, at the eastern end of the area, reported that bed rock was first encountered 25 feet beneath the surface. This depth to bedrock is in keeping with other records in the area.

GLACIAL DEPOSITS

The entire basin of Lake Erie has been covered by at least two of the ice sheets of Pleistocene age. The bedrock in the area studied is overlain with a thin covering of glacial till, which is overlain by about 20 feet of lacustrine clay. In the eastern part the till is about 5 feet thick according to the reported log of a well drilled nearby.

The till is a moist, soft, calcareous clay with very small rock flakes and pink streaks at the top grading downward to a blue-gray clay containing pebbles. Eastward on Lake Erie where the till outcrops it is a hard, compact, clay with rock fragments ranging from sand size to cobbles and boulders.

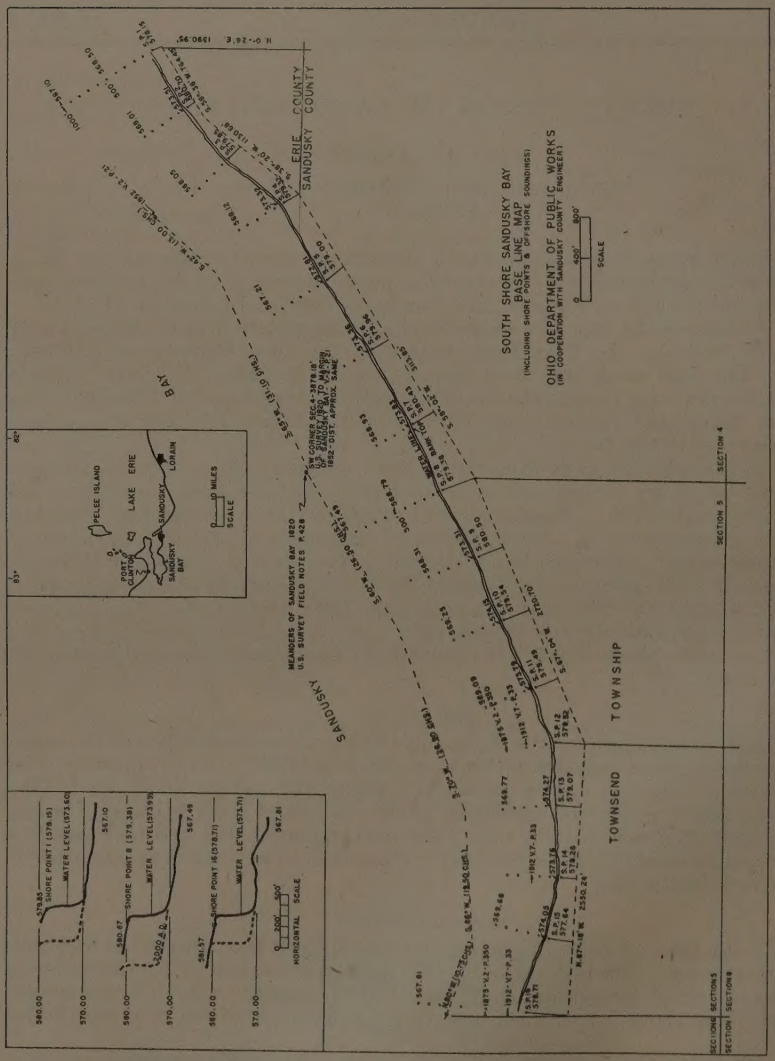

FIG. 1. The 1820 and 1945–1946 Meander Line of Sandusky Bay in the area studied. Insets show location of Sandusky Bay and Profiles at selected Shore Points.

A mechanical analysis of the very top of the till layer showed about 82 per cent of silt and clay sized particles and only 2.1% of material larger than 2 mm. Although the till is rather fine-grained it contains a higher proportion of coarse and fine sand than is found in the lacustrine clay described later.

GLACIAL AND POST GLACIAL LAKES

Introduction

Critical Area 34 and all of Sandusky County, except a very small area in the southeastern corner was covered by the waters of glacial lakes. Beach ridges of sand and gravel, representing offshore bars or shore lines of three of the glacial lakes—highest Maumee, Whittlesey and Warren, are present in the southeastern portion of Sandusky County.

Lacustrine Deposits

In the glacial lakes silts and clays were deposited over the underlying thin glacial till. Some of the material came from finely ground material in the dirty under portion of the ice, and some came from shore erosion on the land areas to the south.

Lacustrine clay forms the surface material everywhere in the area. It composes all of the 7 feet of material in the low cliffs along Sandusky Bay, and continues to depths of 20–22 feet below the surface, below which glacial till occurs.

The fresh lacustrine clay is silty clay, blue-gray in color, with some yellowish-brown mottling, especially in the upper 10–12 feet, and always shows at least faint lamination.

Wilson (1943, pp. 195–197) interpreted the lacustrine clays as varved clays. From studies of his thickest core (which reached bedrock) taken a few feet beyond the southern edge of Sandusky Bay on Lake Erie he counted 12,223 varves in a total thickness of 37' 7." He concluded that the Sandusky Bay region was covered by waters of the glacial lakes for a minimum of 12,223 years. White (1943, p. 39) described the lacustrine clay at the western end of Lake Erie as follows:

"The lacustrine clay is a very weak and easily eroded material. It is affected by frost action, by slaking upon drying in newly exposed bluffs, by rain wash, and by wave attack. The waves remove first the crumbly outer surface produced by frost action and by slaking, leaving a new surface to be further affected by frost and drying. . . . .

"When eroded, the silt and clay are readily carried to deeper water, and the sand in the material is so very small in amount that it makes no significant contribution to the beach."

SHORE EROSION

Shore erosion along Lake Erie and in Sandusky Bay has long been observed. Moseley (1905, p. 179) pointed out the damage to the south shore of Sandusky Bay during northeast storms of 1857–1862 and subsequent years.

From U. S. Survey Field Notes the Sandusky County Engineer's Office was able to determine the margin of Sandusky Bay in the years 1820, 1875, and 1912 along section lines. During the summers of 1945 and 1946 the Lake Erie Division of the Ohio Department of Public Works in co-operation with the Sandusky County Engineers surveyed a base line along the south shore of Sandusky Bay marked by "Shore Points" consisting of pipes set in concrete. The 1945–46 meander line was placed on a tracing and the points along the margin of the bay in the surveys of 1820, 1875, and 1912 were added (Fig. 1).

Along the western border of section 5, Townsend Township, the present shore is about 650 feet farther south than in 1820.

Along the line between sections 4 and 5 of the same township the present margin of the bay is about 1150 feet south of its position in 1820.

The easternmost point of the 1820 survey is about 825 feet from the nearest point on the present shore.

At the point of least retreat (western boundary of section 5) the south shore of Sandusky Bay in Critical Area 34 has been retreating at an average rate of 5.2 feet per year for the past 125 years. At the point of greatest retreat (western boundary of section 4) the shore has been retreating at an average rate of 9.2 feet per year for the past 125 years.

The retreat of the shoreline and enlargement of the bay does not proceed at a uniform rate. Cycles of high water in Lake Erie are evident from the hydrographs compiled by the U. S. Lake Survey. During cycles of high water more rapid erosion of the shore materials occurs. Northeast storms pile water up in the bay and then destruction by waves is severe. Moseley (1905, p. 188) points out that only once in several years is the water level raised or lowered from its normal level so much as 3 feet at Sandusky and extreme fluctuations of 6 or 7 feet at each end of the lake are rare. A change of only several feet, however, would greatly increase the erosive power of the waves. Northeast storms occurring during cycles of high water are especially destructive. During severe northeast storms when the water level is high the water may encroach upon the land at a very rapid rate, then for a period of several years there may be practically no loss of shore materials. The shape of the shoreline and its trend also affects the rate of loss.

FUTURE SHORELINE

Movement of the present shore

Early in the history of Lake Erie, according to Leverett, (1931, p. 101) the area now covered by the waters of Sandusky Bay was occupied by the Sandusky River and its tributaries. Progressive submergence of the western end of the Lake Erie Basin and the mouth of the Sandusky River formed Sandusky Bay. Wave erosion has steadily contributed to the enlargement of the bay. The course of the Sandusky River and its tributaries across Sandusky Bay was carefully determined by Moseley (1905, p. 202). He correctly interpreted the present shoreline as one of submergence and Sandusky Bay as the drowned lower valley of the Sandusky River.

The rate of submergence of the western end of Lake Erie has been studied by several authorities and various rates of change in the land surface proposed. Gilbert (1898, p. 639) makes the following statement: "The water also advances on all shores of Lake Erie, most rapidly at Toledo and Sandusky, where the change is 8 or 9 inches a century." Moseley (1905, p. 235) calculated the rise of water caused by tilting of the land to be 2.14 feet per 100 years at Sandusky. Gutenberg (1933, p. 455) quotes Freeman as estimating the rate of water rise at about 0.5 foot per 100 miles per 100 years. Moore (1948, p. 705) points out that the entire Great Lakes area is subsiding with respect to sea level, the least subsidence on Lake Erie is at the outlet at Buffalo and the greatest subsidence is at Port Clinton, about 6 miles directly north of the area studied on Sandusky Bay. He further points out that Lake Erie is gaining in volume so that there is encroachment of water on the land along the entire shore line.

As subsidence continues Sandusky Bay will become wider and longer and more of the Sandusky River will be submerged. As the bay grows in size shore erosion will take place more rapidly since the waves will attain greater size and force.

Future shorelines

Opposite shore points 1, 8, and 16 (Fig. 1) offshore borings and soundings were made. Samples of the bottom sediment were taken to a depth of 4 feet below the bottom of the bay, and profiles of the bottom were constructed. Different water levels represent different times of study.

The profiles are extended to show the position of the shore in the year 2000

A. D., if the shore materials at these locations continue to be removed at the average annual rates that have occurred since 1820.

The rates of retreat used for projecting the profiles into the future are conservative, and the position of the shore in 2000 A. D. may well be farther inland than shown, as subsidence of the western end of the Lake Erie Basin will probably continue in the future, adding to the size of Sandusky Bay and increasing the rate of encroachment of the water on the land. It may be expected that cycles of high water in Lake Erie and Sandusky Bay will continue in the future, and northeast storms will sometimes occur during periods of high water.

Lowering of lake level by engineering works, or the construction of extensive shore protective devices in Sandusky Bay could slow the rate of shore erosion. Without these the bay will continue to become longer, wider, and shallower.

ACKNOWLEDGMENTS

The writer is indebted to Dr. George W. White, former State Geologist of Ohio, to the late Mr. W. H. Gould, State Agent for the Lake Erie Division, Ohio Department of Public Works, and to Mr. D. W. Gould who furnished valuable assistance in the field and information on the area studied. The Ohio Department of Highways made the grain size analyses of the materials collected. Mr. John H. Melvin, State Geologist of Ohio, gave permission for publication of some of the data.

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A CHANGE IN EDITOR OF THE JOURNAL

Dr. Glenn W. Blaydes has recently resigned as editor of the Ohio Journal of Science. Dr. Blaydes became Associate Editor of the Journal in 1941 and Editor-in-Chief in 1942. During his association with the Journal, Dr. Blaydes has successfully met many problems including the problem of continuing publication during the war years and of changing the format to increase the amount of text per page. The Joint Administrative Board of the Ohio Journal of Science has accepted Dr. Blaydes' resignation with regret.

The new Editor-in-Chief is Dr. Earl L. Green, of the Department of Zoology and Entomology of the Ohio State University. Dr. Green has been Associate Editor during part of the past year.

The editorial policy of the Journal will continue in the pattern established by previous editors. The Journal will welcome and publish papers in all fields of science. The papers may be either technical reports of new research, or expository and descriptive papers on aspects of science of general interest. Especially the Journal offers a means of prompt publication of the results of recent research without any charge to authors and without any delay in the publication of other reports and papers. This may now be accomplished by enlarging each issue as needed. The Journal also bears the cost of printing illustrations for all papers.

CHEMICAL INVESTIGATION OF TWO ANCIENT BRONZE STATUETTES FOUND IN GREECE[1]

EARLE R. CALEY
Department of Chemistry,
The Ohio State University,
Columbus, Ohio

A great deal is known about Greek and Roman statuary bronzes from the standpoint of art, but very little is known about them from the standpoint of chemical composition. Only a few analyses have been made, and most of these are analyses of objects of uncertain or unknown provenance. Our information concerning the composition of Greek statuary bronze is especially meager. By a fortunate chance several bronze objects and fragments of bronze objects were found about fifteen years ago in the filling of an abandoned ancient well in the Agora, or ancient market place, at Athens, Greece, and two of the objects, both of them statuettes, were given to the author for chemical investigation after attempts at restoration were unsuccessful. The archaeological evidence, such as the coins found in the filling of the well, showed that these statuettes had been dropped or thrown in the well at about the end of the second century A. D., so that their immediate provenance is very definitely established. One of the statuettes was a female figure about 10 cm. high, and the other was the figure of an animal, probably a stag, about 6 cm. long and 4.5 cm. high. Both were badly corroded, but each contained a substantial core of essentially uncorroded metal from which samples suitable for microscopic examination and chemical analysis could be taken.

MICROSCOPIC EXAMINATION

Both unetched and etched specimens of metal from both statuettes were examined microscopically by Miss Virginia Sheipline, a senior student in chemistry, to whom the author is indebted for the accompanying photomicrographs. Although specimens of polished but unetched metal from the female statuette appeared to be clean and solid to the unaided eye, the presence of numerous cavities and inclusions was readily apparent on sufficient magnification (Fig. 1). Some of the dark spots that appear in the photomicrograph represent minute cavities or blowholes which were evidently formed in the metal at the time of manufacture. Some of the others apparently represent nonmetallic impurities trapped in the molten metal during solidification. Still others probably represent places where intergranular corrosion has occurred in the course of long burial. After etching with a very dilute mixture of hydrochloric and nitric acids the metal of this statuette was seen to have a peculiar, coarse, dendritic structure (Fig. 2). After etching with an alcoholic solution of ferric chloride containing hydrochloric acid the dendrites had the normal appearance of those in an ordinary cast tin bronze, but the structure was not so easy to photograph because of lack of contrast. The undisturbed dendritic structure showed clearly that the statuette was produced solely by casting. The presence of a great number of globular and irregular particles of metallic lead, varying greatly in shape and size, was apparent in the polished but unetched metal from the animal statuette (Fig. 3). It is evident that the metal contained a very high proportion of unalloyed lead. The metal surrounding the lead, after etching with ammonium persulfate and hydrogen peroxide solution, had a dendritic structure (Fig. 4). Because of its very high lead content, the metal of this statuette was very difficult to etch properly for the purpose of preparing a photo-

[1]Presented in part at the meeting of the Ohio Academy of Science, Columbus, Ohio, April, 1950.

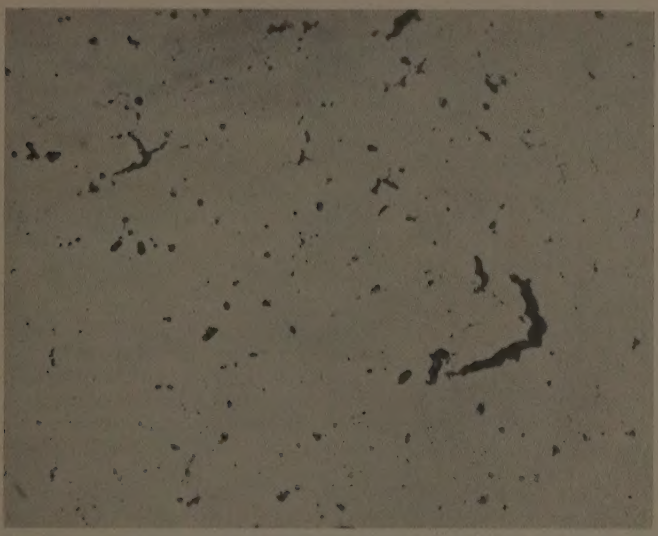

FIG. 1. Photomicrograph of polished but unetched section of metal from female statuette. 150 ×.

FIG. 2. Photomicrograph of etched section of metal from female statuette. 150 ×.

graph, and the dendritic structure in Fig. 4 is not very distinct. However, under the microscope it could be seen that the dendrites were often arranged radially around the larger lead globules and that the lead itself had a coarse crystalline structure. The generally globular shape of the lead particles and the dendritic structure of the matrix showed clearly that this statutte had also been produced solely by casting.

METHOD OF CHEMICAL ANALYSIS

Accurately weighed samples of about a gram were treated with nitric acid for the separation of the tin. After evaporation of the solution to small volume, followed by dilution and digestion, the hydrated tin oxide was filtered off on quantitative paper, washed with hot dilute nitric acid, and ignited to constant weight in an electric muffle furnace. As no pink or purple coloration of the tin oxide was observed in the course of this separation, provision for the separation and determination of gold was not necessary. For the determination of the true percentages of tin, the ignited residues of impure tin oxide were treated with ammonium iodide according to the method of Caley and Burford.[2] The filtrates from the separation of the tin were treated with dilute hydrochloric acid to detect silver. This metal was found to be present in one of the bronzes, and it was separated by adding sufficient hydrochloric acid to precipitate all the silver as the chloride. The precipitates of silver chloride were collected in filter crucibles, washed with dilute nitric acid, and dried in an oven to constant weight. To these filtrates, as well as to those which gave no reaction for silver, the proper volume of concentrated sulfuric acid was added, and after evaporation, dilution, and digestion, the separated lead sulfate was collected in filter crucibles, washed with cold, very dilute sulfuric acid, dried, ignited and weighed. The filtrates from the separation of the lead were electrolyzed, using a platinum gauze anode and cathode. Usually a small amount of lead dioxide deposited on the anode. This was calculated to metallic lead and this weight was added to the weight of the lead found by the sulfate determination so as to give the total amount of lead in each sample. Copper was found from the increase in the weight of the cathode. The filtrates from the electrolytic determinations were evaporated to small volume, and iron was precipitated by the addition of ammonium hydroxide solution. The hydrated iron oxide was filtered off on quantitative paper, ignited and weighed as ferric oxide, from which the weight of iron was calculated. Nickel was determined in the filtrates by precipitation with a solution of dimethylglyoxime, the nickel compound being collected in filter crucibles, washed with water, and dried to constant weight in an oven. After the destruction of the excess of dimethylglyoxime in the filtrates from the nickel determination by evaporation with nitric acid, zinc was precipitated as phosphate in neutral solution by the addition of secondary ammonium phosphate. The precipitates were collected in filter crucibles, washed, dried in an oven, and weighed as zinc ammonium phosphate. Separate samples were examined for arsenic and sulfur but neither of these elements could be detected. This is merely an outline of the method of analysis, many necessary manipulative details being omitted for the sake of brevity.

ANALYSTS AND RESULTS OF ANALYSES

The analyses were made under the direction of the author by Miss Virginia Sheipline and Messrs. W. H. Deebel and N. V. Lovegren. Miss Sheipline analyzed two samples of metal taken from the animal statuette and Mr. Deebel two from the female statuette. Mr. Lovegren analyzed three samples taken from the female statuette and one from the animal statuette. The results shown in Table I are weighted averages from all these analyses. In addition to the elements listed in the table, a small proportion of oxygen was also present in the

[2] Caley, E. R., and Burford, M. G., *Ind. Eng. Chem., Anal. Ed.*, 8, 114–118 (1936).

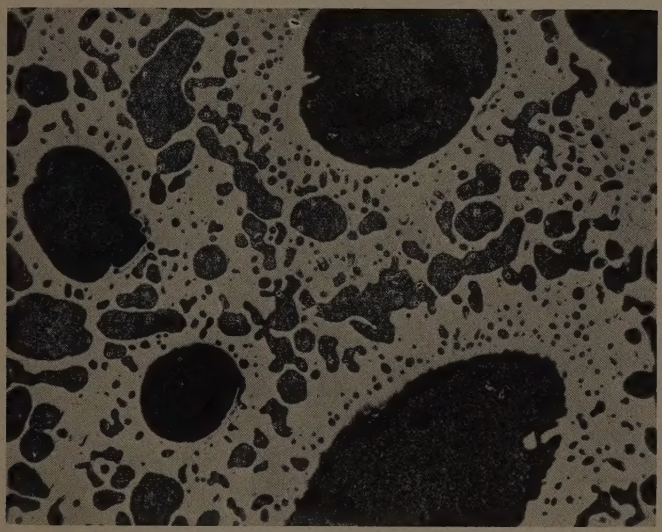

FIG. 3. Photomicrograph of polished but unetched section of metal from animal statuette. 150 ×.

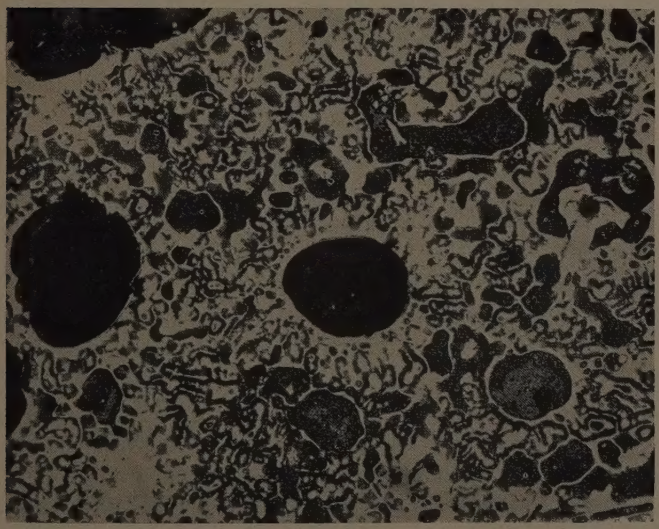

FIG. 4. Photomicrograph of etched section of metal from animal statuette. 150 ×.

form of metallic oxides as shown by the microscopic examination, but no attempt was made to determine this quantitatively.

DISCUSSION OF ANALYTICAL RESULTS

The analysis shows that the metal of the female statuette is an ordinary bronze of moderate tin content containing various impurities commonly found in ancient bronzes. On the other hand, the metal of the animal statuette is an alloy of low tin content and extraordinarily high lead content. In the metal of the female statuette the lead must be regarded as a mere accidental impurity, but in the other it is certainly an intentional component of the alloy. The small proportion of silver in the metal of the animal statuette is in all probability an accidental impurity accompanying the lead. The great difference in the proportions of tin and lead in the metal of the two statuettes is the most striking and significant result of these analyses.

A comparison of the present analyses with previous analyses of statuary bronzes of the classical period brings out some interesting relationships. In Table II are shown, with one exception, all the previous analyses of Greek statuary bronzes that could be located. The one omitted from the table appeared to be unreliable because of the low summation of the analytical results. It will be noted that in these bronzes copper and tin are the only main components and that lead is absent. The apparent absence of such usual impurities as iron and nickel from the

TABLE I

ANALYSIS OF SAMPLES OF METAL FROM THE STATUETTES

Component	Female Figure	Animal Figure
Cu	92.28	60.40
Sn	7.00	3.74
Pb	0.13	34.56
Ag	none	0.22
Fe	0.16	0.33
Ni	0.05	0.09
Zn	0.22	0.40
Au, As, S	none	none
Total	99.84	99.74

first two analyses of Table II is, in all probability, due to the approximate analytical methods that were used. In Table III are shown all the previous reliable analyses of Roman statuary bronzes that could be located. It will be noted that in these bronzes the proportion of tin is generally much lower than in the Greek bronzes of Table II and that lead is always present in considerable proportion. In most of them it exceeds the proportion of tin and must be regarded as an intentional major component. The presence of lead in relatively high proportion appears to be characteristic of Roman statuary bronzes. In addition to this experimental evidence there is literary evidence for lead as an intentional component in Roman statuary bronze, for Pliny,[3] in giving formulas for the composition of the bronze used for statuary, lists lead as a necessary ingredient in all of them.

KEY TO OBJECTS AND ANALYSTS

A. Fragment of statue found in Antikythera. Date about third century B. C. Analysis by Rhousopoulos. Published in Diergart, Beiträge aus der Geschichte der Chemie dem Gedächtnis von Georg W. A. Kahlbaum, Leipzig and Vienna, 1909, p. 187.

[3]Natural History, Book XXXIV, secs. 97–98.

B. Female statue or statuette of fine style. Provenance unknown. Analysis by Göbel. Published in his work, Ueber den Einfluss der Chemie auf die Ermittelung der Völker der Vorzeit oder Resultate der chemischen Untersuchung metallischer Alterthümer, Erlangen, 1842, p. 23.
C. Female statuette. Provenance unknown. Analysis by Bibra. Published in his work, Die Bronzen und Kupferlegirungen der alten und ältesten Völker mit Rucksichtnahme auf jene der Neuzeit, Erlangen, 1869, pp. 88–89.
D. Fragment of statuette. Provenance unknown. Analysis by Bibra, *loc. cit.*

TABLE II

PREVIOUS ANALYSES OF GREEK STATUARY BRONZES

Object	Cu	Sn	Pb	Fe	Ni	Zn	Ag	Sb	S
A	84.74	14.29	.....	.....	.....	.....	.....	.....	.....
B	88.54	11.46	.....	.....	.....	.....	.....	.....	.....
C	88.51	10.13	none	1.02	0.34	none	tr.	tr.	tr.
D	89.96	9.22	none	0.44	0.38	none	none	tr.	none

TABLE III

ANALYSES OF ROMAN STATUARY BRONZES

Object	Cu	Sn	Pb	Fe	Ni	Zn	Ag	Sb	S
A	80.70	9.44	7.68	.....	.....	1.92	.....	.....	.....
B	81.23	9.33	9.34	0.10	.....	.....	.....	.....	.....
C	78.77	9.03	12.07	0.13	tr.	none	none	tr.	tr.
D	72.63	8.19	19.01	0.17	.....	.....	.....	.....	.....
E	80.65	8.13	10.00	0.30	0.17	0.75	none	none	none
F	76.03	7.33	12.11	1.20	0.20	3.03	tr.	tr.	0.10
G	68.62	6.77	24.46	0.13	.....	.....	0.02	.....	.....
H	87.36	6.23	6.20	tr.	0.21	tr.	none	none	none
I	85.64	4.22	9.13	0.80	0.20	tr.	none	none	0.01

KEY TO OBJECTS AND ANALYSTS

A. Statue found at Brescia. Unknown date. Analysis by Arnaudon. Published in *Bull. soc. chim.* 1, 245 (1860).
B. Base of a statue found at Bern. Unknown date. Analysis by Fellenberg. Quoted by Bibra, Die Bronzen und Kupferlegirungen der alten und ältesten Völker mit Rücksichtnahme auf jene der Neuzeit, Erlangen, 1869, pp. 72–73.
C. Statuette of Minerva. Provenance unknown. Analysis by Bibra, *loc. cit.*
D. Statue. Provenance uncertain. Analysis by Fellenberg. Quoted by Bibra, *loc. cit.*
E. Statuette. Provenance unknown. Analysis by Bibra, *loc. cit.*
F. Statuette of Victory. Provenance unknown. Analysis by Bibra, *loc. cit.*
G. Base of statue found at Bern. Unknown date. Analysis by Fellenberg. Quoted by Bibra, *loc. cit.*
H. Statuette of an animal. Provenance unknown. Analysis by Bibra, *loc. cit.*
I. Statuette. Provenance unknown. Analysis by Bibra, *loc. cit.*

This sharp difference between the composition of Greek statuary bronze and Roman statuary bronze is paralleled by a similar difference between the composition of Greek coinage bronze and Roman coinage bronze. Of special interest for the present study is the difference in the composition of the coinage bronze of Athens in Greek and Roman times. The series of typical analyses shown in Table IV were selected from the author's memoir on the composition of ancient

Greek bronze coins.[4] From this table it will be seen that the tin content of the coins of Greek times is invariably higher than in the coins struck in Roman times, and that the lead content is invariably lower. In most of the coins of Greek times, lead is either absent entirely or is present in such small amount that it must be considered an accidental impurity. Only in a small proportion of the coins, as in Nos. 5, 10, and 16 of Table IV, does it appear in high enough amount to be considered an intentional component. In the coins of Roman times it is clearly an intentional component just as in Roman statuary bronze. Lead is also found as a major component in other kinds of Roman bronze objects. Thus it appears to be true in general that Greek bronze is characterized by a relatively high tin content and the presence of little or no lead, and Roman bronze by a relatively low tin content and a high lead content.

TABLE IV

PROPORTIONS OF MAJOR COMPONENTS IN ATHENIAN COINAGE BRONZES

No.	Period	Cu	Sn	Pb
1	Third Century B. C.	87.99	12.05	none
2	" " "	87.06	11.32	1.51
3	" " "	87.49	10.67	1.29
4	" " "	89.64	10.40	0.01
5	" " "	83.57	10.24	5.70
6	" " "	86.01	10.08	3.18
7	" " "	90.04	9.93	none
8	" " "	88.81	9.80	1.36
9	" " "	89.54	9.40	0.54
10	" " "	83.88	9.20	6.38
11	" " "	88.79	8.55	2.56
12	" " "	90.30	8.25	1.28
13	Second Century B. C.	88.74	11.10	0.22
14	" " "	89.03	10.60	0.20
15	" " "	86.38	10.56	2.73
16	" " "	84.96	9.89	5.15
17	First Century B.C.	78.21	7.56	13.26
18	" " "	71.23	6.84	20.38
19	First Century A. D.	70.55	5.93	23.03
20	First or Second Century A. D.	68.05	4.45	26.82
21	Second Century A. D.	63.23	3.89	32.51
22	Second or Third Century A. D.	66.05	4.10	29.32
23	Third Century A. D.	66.19	3.75	29.18

Now if the analyses of Table I are compared with those in Tables II, III, and IV the obvious conclusion seems to be that the animal statuette found in Athens was a product of Roman times and that the female statuette was a product of Greek times. The animal statuette could have been made only a few years before it was deposited in the well, and at the most was probably made less than two centuries before. On the other hand, the female statuette was probably made at least three centuries before it was deposited and could have been made five or six centuries before. On the basis of the archaeological evidence alone, there was no reason to suspect that these two statuettes, which were found together, were not products of the same period, but the chemical evidence strongly indicates, even if it does not definitely prove, that they were products of different periods. This is another example of how the chemical investigation of ancient objects may yield new information about them that may correct or supplement the information derived from the archaeological evidence.

[4] Caley, E. R. The Composition of Ancient Greek Bronze Coins. Philadelphia, 1939.

THE BEDROCK SURFACE AND THE DISTRIBUTION OF THE CONSOLIDATED ROCKS IN MONTGOMERY, GREENE, CLARK, AND MADISON COUNTIES, OHIO[1]

STANLEY E. NORRIS[2]
U. S. Geological Survey,
52 Starling Street, Columbus 8, Ohio

The areal distribution of the different consolidated-rock formations in Ohio depends chiefly on the altitudes and the dips of the beds and on the amount of erosion they have undergone since they were elevated above sea level. In glaciated areas the effects of erosion are generally difficult to determine because of the covering of glacial drift over the bedrock. Only in areas where considerable information is available on the thickness of the glacial drift is it possible to map accurately the areal distribution of the consolidated rocks. Information on the topography of the bedrock surface was not available to earlier geologists, and as a consequence the State geologic maps do not show in detail many areas where certain of the consolidated rocks have been removed by erosion.

The first detailed mapping of the bedrock surface in the glaciated portion of Ohio was by Wilber Stout, former State Geologist, and was published by the Ohio Geological Survey as part of a bulletin on the ground-water resources of the State.[3] Stout outlined the principal buried valleys and discussed the preglacial drainage systems and their erosion cycles. More recently, as a result of an intensive investigation of the water resources of the State being conducted by the U. S. Geological Survey and the Ohio Department of Natural Resources, Division of Water, much additional information has become available on the bedrock surface of the west-central part of the State, principally in Montgomery, Greene, Clark, and Madison Counties. From data obtained from well drillers and from field studies, the thickness of the glacial drift has been determined at numerous places and contours having a 50-foot interval have been drawn on the bedrock surface. Information is sufficient to outline the main buried valleys and to determine approximately the altitudes of their floors. Maps have also been drawn showing the areal distribution of the consolidated rocks, based on the altitudes and the dips of the beds, and on the irregularities of the bedrock surface. This information is being published by the Ohio Division of Water in the form of bulletins on the water resources of the respective counties under discussion.[4] Except in the case of Madison County the geologic data are shown on base maps made up of the standard U. S. Geological Survey topographic quadrangle maps having a scale of approximately 1 inch to the mile; the base for Madison County is approximately 1 inch to two miles.

The floors of the buried valleys in west-central Ohio were eroded to altitudes of approximately 500 feet above sea level before the valleys were filled with glacial

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[1]Published by permission of the Director, U. S. Geological Survey.

[2]Geologist, Ground Water Branch, U. S. Geological Survey, Columbus, Ohio.

[3]Stout, Wilber, Ver Steeg, Karl, and Lamb, G. F., Geology of Water in Ohio: Geol. Survey of Ohio, 4th ser., Bull. 44, 1943.

[4]Bulletin 12, The water resources of Montgomery County, Ohio, by Norris, S. E.; Cross, W. P., and Goldthwait, R. P., 1948.
Bulletin 19, The water resources of Greene County, Ohio, by Norris, S. E.; Cross, W. P., and Goldthwait, R. P., 1950.
Bulletin 22, The water resources of Clark County, Ohio, by Norris, S. E.; Cross, W. P., and Goldthwait, R. P., (in preparation).
Bulletin —, The water resources of Madison County, Ohio, by Norris, S. E.; Cross, W. P., and Goldthwait, R. P., (in preparation).

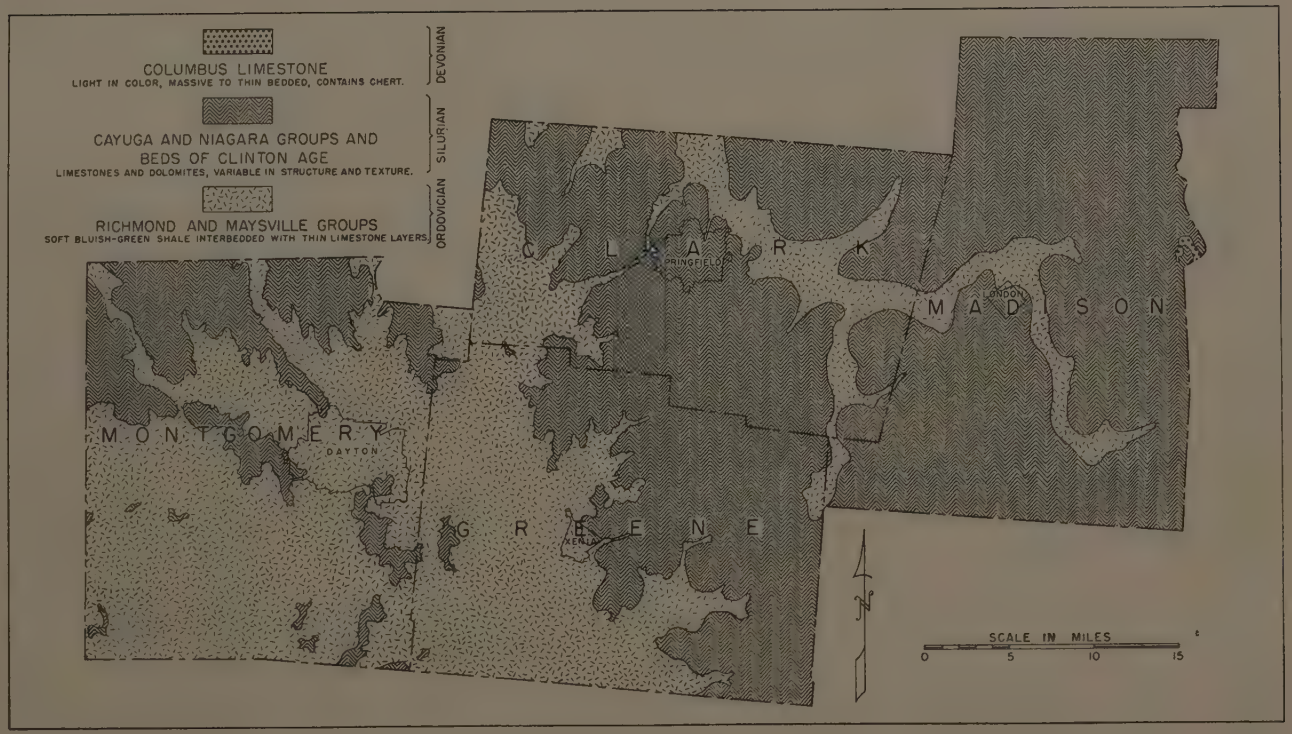

FIG. 1. The distribution of the consolidated rocks in Montgomery, Greene, Clark, and Madison Counties, Ohio.

drift. The present altitude of the land surface in parts of Clark and Madison Counties is more than 1,100 feet above sea level, indicating maximum depths to bedrock of as much as 600 feet where areas of highest altitude coincide with the buried valleys. The greatest known thickness of drift within the area is approximately 3 miles northwest of London in Madison County, where a well at the State prison farm failed to reach bedrock at a depth of 520 feet. Another well, at the Springfield waterworks in Clark County, penetrated bedrock at the depth of 422 feet, or at an altitude of approximately 548 feet above sea level. In areas of former drainage divides, bedrock occurs at altitudes of more than 1,000 feet above sea level. Preglacial relief, therefore, was on the order of 500 feet, which is considerably greater than the present relief of the area. The incising of the consolidated rocks to such great depths by the preglacial streams has had considerable effect on the areal distribution of sub-drift outcrops of the rocks, because many of the younger formations have been removed by erosion along the axes of the buried valleys.

The average dip of the consolidated rocks in the area under discussion is approximately 13 feet per mile to the northeast. The dip was measured on the shale at the top of the Richmond group of Ordovician age, a convenient and well-marked stratigraphic horizon. The Cincinnati anticline is the dominant structural feature of western Ohio. The dip of the beds ranges from nearly horizontal in parts of Montgomery County, which is near the crest of the anticline, to a maximum of about 40 feet per mile in eastern Madison County, which is on the eastern flank of the anticline. The top of the Richmond group crops out in Montgomery County and in western Greene County at altitudes ranging from about 980 to 850 feet above sea level. In eastern Madison County the top of the Richmond group is as low as 300 feet above sea level, or as much as 650 feet below the present land surface.

As shown on the accompanying plate (Fig. 1), Ordovician rocks crop out beneath the glacial drift in most of Montgomery County, in much of Greene County, in the buried valleys in Clark County, and in part of Madison County. Rocks of Silurian age make up the bedrock in most of the remaining area, and Devonian rocks, the youngest strata of the area, are confined to a small erosional remnant in eastern Madison County.

In some parts of the State adequate ground-water supplies cannot be obtained from the glacial drift. In such areas it is important to know the areal distribution of the consolidated rocks. Especially is this true because of the great differences in the water-bearing properties of those rocks. In west-central Ohio adequate water supplies for farm or domestic purposes are generally available from the Silurian and the Devonian rocks, whereas satisfactory supplies can seldom be obtained from the Ordovician rocks. Precise knowledge of the areas underlain by the consolidated rocks, therefore, might, in certain cases, prevent much needless expense by eliminating useless drilling for rock formations that may not occur at the site being prospected.

The present investigation of the ground-water resources of Ohio has recently been extended into Champaign, Franklin, and Pickaway Counties. Detailed information on the bedrock surface and the distribution of the consolidated rocks in those counties should aid greatly in determining whether water-bearing consolidated rocks are present at sites chosen for prospective ground-water developments, and in addition constitute an important contribution to the geologic knowledge of the State.

ADDITIONS TO LIST OF OHIO LEAFHOPPERS

(HOMOPTERA: CICADELLIDAE)

DOROTHY J. KNULL
330 E. Dunedin Road,
Columbus 2, Ohio

Since publication of the "Check List of Ohio Leafhoppers" by Herbert Osborn and Dorothy J. Knull, *Ohio Journal of Science* 46: 329-336, 1946, 29 additional species have been found. The form of the Check List is followed in listing them; locality records published before are omitted.

Collectors are D. J. & J. N. Knull unless others are mentioned, and determinations are those of the author, with one exception.

Gyponana fagi DeL., Delaware Co., July 12, 1946.

orientala DeL., Clifton, July 7, 1947.

pruinosa (Spångberg), Greene Co., June 20, F. W. Mead.

Scaphoideus atlantus Ball.

baculus DeL. & Mohr is a synonym of **luteolus** V. D.

camurus DeL. & Mohr, Columbus, July, 1947.

crassus DeL. & Mohr, Columbus, July 4, F. W. Mead; Fairfield Co., June 26, 1946; Hocking Co., July 4, 1945.

(*flexus* DeL. & Mohr is a synonym of **incisus** Osborn as noted in Check List; through error *flexus* was not italicized.)

radix DeL. & Mohr, Columbus, July 28, 1928, C. C. B. Mayer.

Sorhoanus orientalis (DeL. & Davidson), Clifton, June 3 and 16, 1947; Delaware Co., June 15, 1947; Fairfield Co., June 26, 1945; Hocking Co., June 10, 1947.

Dikraneura hamar Ross & DeL., Fairfield Co., July 30, 1947; Hocking Co., Sept. 14, 1944.

Joruma pisca McAtee, Delaware Co., July 22, 1945; Hocking Co., Aug. 16, and Sept. 14, 1945. Determined by P. W. Oman.

Typhlocyba danae McAtee, Delaware Co., June 20 and July 5, 1945.

surcula DeL. & Johnson, Hocking Co., June 20.

tortosa Ross & DeL., Delaware Co., June 14, 1945; Scioto Co., June 1 and 9, 1945.

Erythroneura (Obliqua Group) ohioensis Knull.

(Maculata Group) ballista Beamer, Hocking Co., Sept. 16, 1948; Greene Co., April 28, 1949.

direpta Knull.

externa Beamer, Delaware Co., Aug. 24, 1944.

flexibilis Knull.

hymettana Knull.

lata Beamer, Hocking Co., Sept. 16, 1943; Scioto Co., June 10, 1944.

linea Beamer, Hocking Co., April 12, 1945 and 1948.

macra Beamer, Delaware Co., April 30, 1944; Hocking Co., April 12, 1945.

malaca Knull.

prolixa Knull.

stephensoni Beamer, Hocking Co., April 12, 1949; Sept. 14, 1945.

stupkaorum Knull, Hocking Co., Sept. 14 and 16, 1944.

teres Beamer, Hocking Co., April 12, 1949; Clifton, April 19, 1948.

trautmanae Knull, Delaware Co., Oct. 9, 1942; Hocking Co., April 12, 1945.

univittata Robinson, Fairfield Co., Sept. 13, 1945; Pickaway Co., Feb. 20, J. S. Caldwell.

MYRMECOLOGICAL TECHNIQUE

IV. Collecting Ants by Rearing Pupae

CLARENCE HAMILTON KENNEDY
Department of Zoology and Entomology,
Ohio State University,
Columbus, Ohio

The nest sought for by the collector, the prize nest of the day's trip, is one which contains all castes in numbers. We have criticized previous ant collectors because up to the present time most collecting has been done by use of a garden trowel. The collector with only a garden trowel (and a scout axe for timber ants) usually collects more ants but more frequently arrives at his laboratory with many missing castes. (We have wished each Christmas for an easily protable steam shovel which could lift a whole next out of the ground and set it down on a large bed sheet, 108 in. by 90 in., with perhaps two folding camp chairs for the collector and his assistant.) We have actually arrived at the use of a shovel with a four-foot handle and a full sized timber axe besides a scout axe and wood chisel. But we now do much of our collecting with a table spoon!

A table-spoon carried in a vest-pocket or a pocket of the collecting bag gives us the most successful collecting we have found yet. With the spoon go two to four 1-quart glass Mason fruit jars which are usually carried in coat pockets or even better in the leg pockets used in the army uniforms of certain soldiers. More jars are carried in the nearby parked car. (The car carries the lunch which limits its distance from operations so that more jars can be obtained at lunch time and used or filled jars can be stored in the car which is usually parked in a shady place, good for the lunch and good for ants in Mason jars).

The large shovel or large axe is usually used first for the rough exposure of the nest. If cells or chambers of pupae are uncovered these are removed by carefully sliding the spoon under them, usually including a considerable amount of the sand, dirt or trash of the pupal bed. The spoonful of bed and pupae are carefully slid into the open Mason jar. Usually enough of the pupal bed is slid into the Mason jar to fill it to one-fourth or one-third of its possible capacity. Worker ants are included to open the cocoons of silk-covered pupae and to care for any young ants which emerge. In the field a note is placed in the jar giving date, locality and moisture condition of the nest, dry, moist or wet. If ether has been used, a breath or two into the jar before covering with the lid will usually remove extra ether below a level dangerous to the pupae and workers in the jar. The cover is tightly applied.

On return to the laboratory the Mason jars are numbered and recorded after opening each jar and blowing more breath in to remove any ether that has come out of the collected nest during transportation. Usually blowing out of ether is repeated the following day or two, if the nest has had a heavier dose of ether in the field than is usually given. Some very active species take a surprising amount of ether during the process of opening and collecting the nest.

In the laboratory these jars of ants and cocoons each representing one nest are fed and checked each day or two. As emerging ants appear on tipping the jar on its side, light etherization is used to quiet the nest, the lid is removed and the whole contents of the jar are dumped on to a newspaper or a flat surface in bright sunlight where all ants can be inspected. Mature winged ants are removed by fingers or tweezers and placed in vials of 70° alcohol. If unopened pupae remain, all workers and unopened pupae are returned to the jar to be resorted for later emergence. The vial (1 drahm) is labelled to match the general field label already

in the jar and is deposited in the jar on top of its nest contents to be removed to the collection when the nest is finally cleaned up. Tenerals, too immature in color or hardness of the exoskeleton are returned to the jar to mature. We have left such in the jar for a week or two.

The workers in the rearing jar have to be watered and given air. Watering is done by pipette using perfectly fresh water. A few drops a day suffice. The nest material should be kept relatively dry, usually slightly dryer than found in the field, to keep fungus down. One season while the process was in development we lost all cultures by fungus which would develop almost over night. On cleaning up the culture jars at the end of the summer session (Univ. of Mich. Biol. Sta., Douglas Lake, Mich.) we found that our assistant of that year had hidden a table glass of water with pipette among the Mason jars and rather than walking the length of the laboratory room (Houghton Hall) to obtain fresh water each day, had merely squirted stale water into each culture without even observing the wetness or dryness of the jar contents. The glass of water was soupy with bacteria, protozoa and fungus. Such cultures were lost to masses of filamentous fungi, a loss of several hundred dollars in gasoline, collecting time, board and other expenses. This particular loss was more than usually serious as that summer was followed by an "open winter" with scanty snow. More than half of all nests in that area were destroyed by freezing. Whole areas of some species disappeared. The ants that remained had special local protection, such as nests in deep ravines, nests four feet deep or under drifted logs.

Cultures have to be fed. As the majority of northern (Canadian-border) ants are honey-dew feeders, cane sugar on a small (2 x 4 in.) rag suffices. Sugar and a few drops of water to keep the sugar drinkable are added every few days. This suffices for a jar worker-population of 10–100 Formicas, large (*rufa*) or small (*Microgyna*). On the possibility that our culture may need fresh meat small parts of large live insects are tossed into the jar. In our studies in northern Michigan and southern Ontario we have not determined whether insect flesh is actually necessary.

In the summer of 1950 we have had complete success with this culturing process. In other years while the process was being tried out we have had trouble in bringing some species of Camponotus through. We did not succeed in determining whether the lab was too dark and cool or the season was not long enough. These ants appear in winged form in the nest in late summer and fly in the following spring. The species studied (undescribed), worked all night in the jars and was quiet in the daytime. We have taken all of its winged forms from nests in the field the latter part of August.

Ants have to have fresh air while being reared in Mason jars. We find that usually sufficient air can be supplied merely by removing the lid and blowing into the jar a full breath of air from the caretaker's mouth perhaps helped by giving the jar a rotation on its side so that stale air is blown out of the nest contents, dirt, sand, wood particles or what not at the end of the process of areation. Quickly the cover is replaced as airing the nest contents in the lower half of the jars stirs up the ants in the nest material whereupon many may rush to the top of the jar and may escape. In quieter species the rotation or shaking up of the nest may be omitted. A puff of breath in the mouth of the jar which may not disturb the ants can be followed by leaving the cover off 10–15 minutes for aeration. This uncovering is risky if several jars are under observation as the caretaker's attention may stray away and some ants may escape.

A further method was tried. I instructed my assistant, Mr. John Moser, senior student in entomology at O.S.U., to procure fine brass or copper screen which could be soldered across the top of the ring of the Mason jar cover. The flat inner disc cover that holds the rubber ring in canning was to be removed. This gave the can a screen top through which air could pass with some freedom. In

making this screen covers for the Mason jars Mr. Moser found several bits of information about Mason jars and bronze or brass screen. He found three types of Mason jars. The one common in grocery and hardware stores has a short neck, so short that the brass screen has to be soldered across the exterior top of the ring of the screw-top. This is the Kerr Mason jar. The glass jar has four flat sides which saves space on the rearing table. We usually use this in the field as the jars fit together in a box or basket in the car. A second kind available in the U.S.A., has a longer screw-top or neck and a taller lid ring. This is the Ball Mason jar. It is less easy to obtain and appears to be going off the market. There is enough space under the taller lid to solder the screen on the inner or underside of the ring lid makes a smoother, more finished screen top. In Canada we found a second brand, Canadian "Jewel," of long necked Mason jar in which there is enough space under the taller lid to solder the screen on the inside of the ring top. This is not available in the States.

There are various sizes of mesh. No. 80 mesh was found to work. 60 mesh worked also. The latter is that usually available as it is used widely for milk strainers.

Two kinds of solder are available (1) wire solder in which the flux or acid runs through it as a fine core. It is used with a hot soldering iron, electrical or gasoline heated. (2) The other comes in paste tubes, is cold, soft and squeezed out and used cold. It hardens rapidly. This paste type comes in two kinds, "general," which is the one for ant jars, and "radiator," which is used on auto radiators. The other tool necessary is a small heavy scissors or "tin snips" to cut the round discs of brass screen.

John Moser finally came to collecting the nests in the field in tight, regular, Kerr Mason jars, and later in the lab to rearing the nests in the screened jars.

For the first time in about twenty summers of collecting ants from the Great Smokies in eastern Tennessee north to western Ontario, the writer feels that this type of summer entertainment has come under a technique of control. We admit we have had a slow, cold, late season (1950) so that we have found early (May, June) emerging species in numbers in June and July. We point out also that for number of species the season of 1950 has been one of the poorest because it was preceded (1949–1950) by an "open winter" with light irregular snow fall which gave the overwintering nests little snow protection from freezing.

The Chicago University Zoology Department's Rearing Method.—The use of open glass battery jars. This method was brought to the U.S.B. Lab. from the University of Chicago by Miss Mary Talbot and has been referred to as the Chicago method. The writer has not run across it in the literature and cannot give credit to its originator. At the time Miss Talbot brought it from Chicago Allee, Emerson and Schneirla were active on the behavior of social insects. The Chicago method, if painstakingly used with reference to air, water and food, has always been successful.

It can be awkward in the usual restrictions of laboratory space: Mason jars save space in field as well as lab. The Chicago method as usually used involves glass battery jars. In nearly every set-up of jars these are too large to be carried to the field. Means to collect the nest in the field, then to transport it to the lab have to be provided. Sometimes a small cloth sack that can be tied tight at its top is used, sometimes a large-mouthed bottle can be used for transportation. Soft pupae in a sack can be injured which may start the eating of injured pupae by workers, if the food supplied the nurse workers is not satisfactory or adequate.

The most convenient size of battery jar, especially for the rearing of winged forms for identification only, is 6 x 8 inches. These take the least space on a rearing table. Around the inner surface of the edge of the jar is smeared a ¾-inch wide band of stiff engine cup-grease. The majority of our common ants will not walk

across such a band. Engine cup-grease in hot weather is stiff enough to hold its form and not run.

Troubles can happen in handling live animals. Their wits are pitted against the caretaker's wits. Covers for battery jars have to be at hand as do covers for Mason jars. The cup-grease may not be fully effective. Some individual ants may defy it. Types of cup-grease are not fully uniform. Some stop ants less often than do other batches. Apparently if held over a year or two some element of the grease drys out leaving a residue less offensive to ants. A plane of glass for cover can stop ants that are not stopped by grease.

Associated with the collection and rearing of pupae is the knowledge of when ants in the field will be found in the pupal stage. This means that good ant collecting will be done by the field students who cover one collecting area season after season until they have a fairly full knowledge of when the ant species of that area will be bringing off brood. Collecting pupae cannot be successful before or after pupae appear in the field.

In earlier days the present collector covered as much ground as possible. If pupae were not present the queen was dug for until the nest was destroyed. Later visits were useless. We do less and less of such destruction with more experience. One good nest carefully collected for rearable pupae is more valuable than a day's work rushing from nest to nest sampling.

The collector should get into the field early which means on the Canadian border by late May or early June, locate good areas and watch thrifty nests until pupae appear. Some very early species (Prenolepis) and some late species (Camponotus) may be missed. This produces a summer collection with males and females in many nests of many species. This method gives identifiable material. If well described it avoids the rehash and re-rehash of ant taxonomy. Probably Emily Post would approve of this consideration of subsequent students.

FORMATION OF THE ENTOMOLOGICAL SOCIETY OF CANADA

At the eighty-seventh annual meeting of the Entomological Society of Ontario, held at Guelph on November 1–3, 1950, it was decided to form a national society, to be called the Entomological Society of Canada. The new society will serve as a link between the various regional societies, namely, the Acadian Entomological Society, the Entomological Society of Ontario, the Entomological Society of Manitoba, the Entomological Society of British Columbia, the proposed entomological society of Quebec, and others that may be established. *The Canadian Entomologist* will be published jointly by the Ontario and the national societies, Dr. W. R. Thompson continuing as Editor, with Dr. G. C. Ullyett as Associate Editor.

W. A. Ross, Division of Entomology, Ottawa, was elected President, and Professor A. W. Baker, Ontario Agricultural College, Guelph, Vice-President. R. H. Wigmore and A. B. Baird, Division of Entomology, Ottawa, have been named Secretary and Treasurer respectively. The Directors comprise the presidents of the regional societies, namely, D. D. Pond, Fredericton, N. B.; W. N. Keenan, Ottawa, Ont.; C. A. Smith, Winnipeg, Man.; and Prof. G. J. Spencer, Vancouver, B. C.; as well as Father O. Fournier, President, Montreal Branch of the Entomological Society of Ontario; Dr. C. W. Farstad, Dominion Entomological Laboratory, Lethbridge, Alta.; and Dr. A. S. West, Queen's University, Kingston, Ont.

The annual meeting of the national society will always be held jointly with the annual meeting of one of the regional societies. In 1951, the combined meetings will be held at Ottawa.

ADVANCES IN WATER WORKS EQUIPMENT AND PRACTICE IN THE PAST FIFTEEN YEARS[1]

SAMUEL SHENKER
Chemist, Water Purification Plant,
Columbus, Ohio

"Water," says the humorist, "is something that they put under bridges." We take it for granted and only when the well goes dry do we do anything about it if we do anything then. Only a few per cent of any community know anything about their water works system and I suppose that we, i. e., water works men, are largely to blame ourselves. Within the past five years or so, the American Water Works Association has started a program to stimulate interest in water works personnel to inform the public about the function of their department. The slogan is "Silent Service is not Enough."

The importance of water was brought into focus within the past six months, or so, when a low of 37% of the capacity of the reservoirs of New York City was reached. I suppose that you read of many incidents that occurred in New York because of this shortage. Here in Columbus in February of 1945 we only had about three feet of water in each reservoir and only one day of thawing weather, when the temperature reached 70° F., saved us from going completely dry because of the severe weather. To date our supply has not been increased substantially. In Loudonville, Ohio, only a few years ago, you may remember that about half the population of 2500 contracted gastro-enteritis because of a slipup in operation and probably planning.

The beginning of modern water purification goes back to 1829 when James Simpson constructed a slow sand filter in London, England. Previous to that time even as long ago as the beginning of the modern era, alum had been used to clarify turbid waters and methods of clarification by repeated settling and decantation had been used. Then, about the middle of the 19th century Koch's spectacular work on micro-örganisms stimulated thinking along the line of removal of pathogenic organisms.

The first filters to be built in this country were installed in Poughkeepsie, N. Y., in 1870, and the first filter plant to use alum was constructed at Somerville, N. J., in 1884. In that year Alpheus Hyatt secured a patent for the process of the use of alum as a coagulant. One of the stalwarts in the design and construction of water works plants, Mr. George W. Fuller and an associate Charles Hermany introduced rapid sand filters in 1895 to 1897 which has served as the basis for the design of mechanical filters constructed in this country. The Columbus plant, which went into operation in September, 1908, was the first combined softening and filtration plant. George A. Johnson did some preliminary analyses and experimental work to determine the physical and chemical characteristics of the Scioto River water over a period of time which aided John H. Gregory, the designing engineer for the George W. Fuller Company in determining the layout of the plant.

The Columbus plant remained the largest combined softening and filtration plant until 1939 when a 100 MGD plant went into operation at Glendale, California, designed by the consulting firm of Hoover and Montgomery. This is a lime-zeolite softening plant and the water is obtained from Boulder Dam 350 miles away, and the waste water is run into a sewer of the city of Los Angeles and is conducted a number of miles to the ocean. This plant was superseded in size by that of Minneapolis in 1940 with a capacity of 120 MGD. Then the Chicago

[1]Paper given before the Chemistry Section of the Ohio Academy of Science, Capital University, Columbus, Ohio, April 28, 1950.

South District Filtration Plant went into operation in 1947 with a rated capacity of 300 MGD at a filtration rate of 2 gpm/square foot with an anticipated maximum capacity of 600 MGD at double the filtration rate. The plant has already treated 550 MGD. At this point it is interesting to note that both Chicago and New York use over a billion gallons of water a day, or about as much water as is stored in our own Griggs Dam when it is filled.

The primary reason for treating water is to improve its sanitary quality. In the period 1901-1908, before the Columbus plant went into operation, the average typhoid fever death rate in Columbus was about 55 per 100,000 population per

FIG. 1. This is a photograph of a spiractor installation showing a spiractor water treatment tank followed by filters which remove any turbidity carryover from the tank. These units eliminate the sludge problem. (By courtesy of the Permutit Company, New York City.)

year. Since 1917 we have had very few deaths here due to typhoid fever. That is true wherever treatment plants have been installed in the country. Water is also softened so as to reduce soap consumption in the home and elsewhere such as laundries and aids in reducing scale in the lines and in boiler tubes. Proper treatment is also an aid in the prevention of corrosion.

There are various types of water supplies, viz.:

1. Surface Waters.
   a. Those that traverse limestone beds, such as here in Columbus. These waters pick up calcium and magnesium from the limestone which causes the hardness in the water.

b. Those that traverse beds, such as the New York City supply. These waters are naturally soft since they do not pick up any calcium or magnesium.

c. Lake waters, such as the supplies in Cleveland and Chicago. These waters are moderately hard, 7 to 9 grains per gallon, and until recently have not been softened.

2. Ground Waters—All of these are hard waters.

a. Isolated aquifers, such as the supply of Lancaster, Ohio.

b. Systems of somewhat connected aquifers, known as underground streams, such as the Newark River from which the Mead Paper Co. of Chillicothe, Ohio, pumps about 20,000,000 gallons per day.

c. Infiltration from streams to gravel deposits adjacent to the stream, such as the former Columbus water supply along the Olentangy River opposite the present Municipal Light Plant where the city had six, six-inch wells.

d. Artesian wells as represented by the present Columbus water supply at the Alum Creek Plant. These waters are very hard.

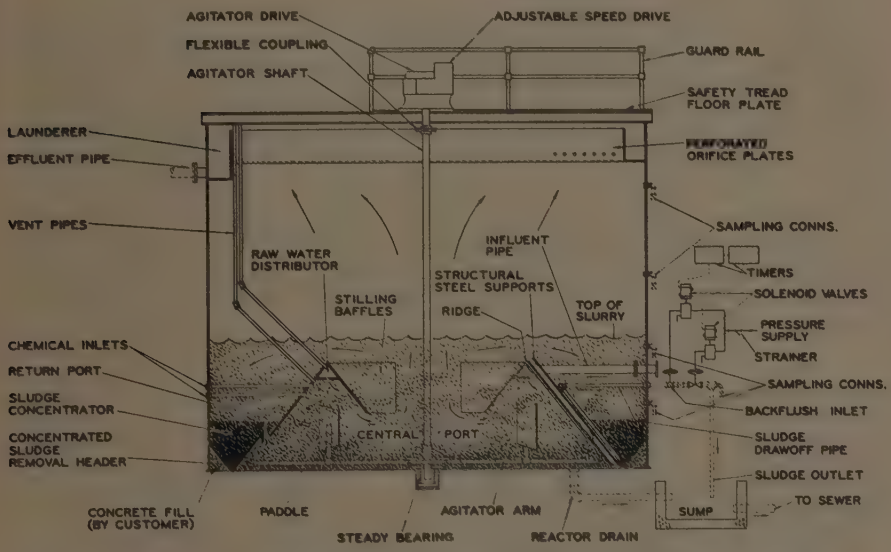

FIG. 2. This is a cross-section of the Cochrane Corporation's "Liquon" sludge contact reactor. This unit secures coagulation, clarification, sludge removal, and utilization of the sludge all in one tank. (By courtesy of the Cochrane Corporation of Philadelphia, Pa.)

The original Columbus plant consisted of square mixing tanks with vertical agitators revolving at low speed, a baffling tank where the water travels up and down vertically, settling basins which remove the sludge, rapid sand filters and a clear well. The next step in the design of water works equipment was the development of the clarifier by engineers of the Dorr Company in about 1920. Clarification and sludge removal was obtained in a single unit. Then in 1935 Charles Spaulding, of Springfield, Illinois, introduced the tank which bears his name and the Permutit Company bought his patents. This plant carries out mixing, coagulation, clarification, and utilization of the sludge to bring the water into chemical balance.

The Minneapolis plant is constructed with units of this type. The International Filter Company of Chicago also developed a unit of this type as did also Samuel Applebaum. The former is called an Accelator while the latter is called a sludge contact reactor. The village of Pataskala, Ohio, has an Accelator water treatment unit while there are sludge contact reactors at the Walnut Station and Poston Station of the Columbus & Southern Ohio Electric Company.

About 7 or 8 years ago a Czech engineer developed a new principle in water treatment known as catalytic precipitation. The patents were purchased by the Permutit Company. This unit consists of a conical covered tank with point downward and the inuflent and chemical feed lines just above the point of the cone. The aggregate is a granular catalyst screened to the proper grain size. The advantages claimed are:

1. The reaction goes to completion in 5 minutes.
2. Considerable saving in space and cost of installation.
3. No sludge waste to handle, only a little enlarged catalyst, to draw off occasionally, which can be broken up and reused, or disposed of readily.
4. No agitation required.
5. Units are relatively portable.

These units are called spiractors.

The tremendous, new Chicago filtration plant was carefully designed by some of the leaders in the water works field. One of the problems that Mr. Baylis solved in the laboratory before the plant went into operation, or even before it was at the blue print stage, was that of eliminating the deleterious effect of algae on the filters. Algae forms a slime on the filters which reduces the length of filter runs and is difficult to wash out. Mr. Baylis developed an aid to coagulation, viz silica sol, which hardened the floc and gave rapid filtration. Another problem that was solved to a great extent in this plant was that of air-binding of filters. This was accomplished by increasing the depth of water on the filter to about 7 feet whereas previously filters carried three to four feet of water over the sand. Two laboratory innovations in the Chicago plant are:

1. A centrifugal machine to concentrate organisms in the filtered water, and
2. An electronmicroscope.

LIME-SODA TREATMENT PLANT SOFTENING REACTIONS

1. $Al_2(SO_4)_3+3Ca(HCO_3)_2=2Al(OH)_3+3CaSO_4+6CO_2+3H_2O$
2. $Ca(HCO_3)_2+Ca(OH)_2=2CaCO_3$
3. a. $Mg(HCO_3)_2+Ca(OH)_2=MgCO_3+CaCO_3+2H_2O$
   b. $MgCO_3+Ca(OH)_2=Mg(OH)_2+CaCO_3$
4. $CaX+Na_2CO_3=CaCO_3+2NaX$

   Where X = anion, such as chloride, sulfate and nitrate.

Alum is the coagulant and removes the turbidity and most of the bacteria by the mechanical action of the aluminum hydroxide.

Lime reduces the carbonate hardness, calcium and magnesium bicarbonates, acts as an antiseptic in excess and also aids in the removal of magnesium when used in excess treatment.

Soda reduces the non-carbonate hardness, i. e., the chlorides, sulfates, and nitrates of calcium and magnesium.

The chemicals underscored are insoluble and form part of the sludge which is wasted. For every pound of quicklime used three and one-half pounds of calcium carbonate are formed.

ION EXCHANGERS

As far as is known, Robert Gans in 1906 was the first man to suggest the use of ion exchange materials for water softening. Both processed natural minerals,

so-called greensands, which are found in New Jersey and Nebraska, mainly the mineral glauconite, and synthetic materials have been developed with varying suitability for ion exchange uses.

Possibly the most significant development in water works materials in the past 15 years was that of the new class of synthetic resins, disclosed in 1935 by Adams and Holmes. The cation exchange resins are mainly sulfonated condensation products. Anion exchange resins are condensation products containing amino groups.

Ion exchange materials fall into three general groups:

1. Inorganic cation exchangers
2. Organic cation exchangers, and
3. Organic anion exchangers.

In the softening reactions, the inorganic exchanger is designated by Z and the organic exchanger by R. The reactions of the calcium salts with the ion exchangers are considered typical.

$$Ca(HCO_3)_2 + NaZ = CaZ + 2NaHCO_3$$
$$CaCl_2 + NaZ = CaZ + 2NaCl$$

Regeneration creates this reaction:

$$CaZ + 2NaCl = NaZ + CaCl_2$$

Whenever hard water is run through ion exchangers after the capacity of the volume of ion exchanger is used up, carbonate builds up on the grains of the zeolite. In the case of the organic ion exchangers they can be cleaned with dilute acid, washed free of the acid and then can be used again. In the case of the inorganic ion exchangers, the minerals are destroyed by the action of acids. Any buildup of carbonate reduces the capacity of the inorganic ion exchanger and nothing can be done about it.

Organic cation exchangers may be operated either in the sodium or hydrogen cycle, since they are unaffected by dilute acids used in regeneration for the hydrogen cycle. Reactions of these materials in the sodium cycle are the same as for the inorganic exchangers above. Typical reactions in the hydrogen cycle are:

$$Ca(HCO_3)_2 + 2HR = CaR_2 + 2H_2CO_3$$
$$CaCl_2 + 2HR = CaR_2 + 2HCl$$

Regeneration

$$CaR_2 + H_2SO_4 = 2HR + CaSO_4$$
$$CaR_2 + 2NaCl = 2NaR + 2HCl$$

Through the use of a regenerant consisting of a mixture of a sodium salt and an acid, some of the organic cation exchangers can be used to reduce or eliminate the bicarbonates from raw water, at the same time substituting sodium for calcium and magnesium in sulfates and chlorides present. With this type of regeneration, the exchanger operates in effect, in both hydrogen and sodium cycles:

$$Ca(HCO_3)_2 + HR = CaR + 2H_2CO_3$$
$$CaSO_4 + 2NaR = CaR_2 + Na_2SO_4$$

Regeneration with NaCl and H_2SO_4

$$2CaR_2 + H_2SO_4 + NaCl = 2HR + 2NaR + CaSO_4 + CaCl_2$$

Anion Exchangers

Reactions:

$$RNH + HOH + HCl = RNH_2 + HCl + H_2O$$

The same type of reaction is obtained with sulfuric or nitric acid.

Regeneration with NaOH

$$RNH_2 + HCl + NaOH = RNH_2 + HOH + NaCl$$

Sodium carbonate is used as a source of alkalinity for regeneration of anion exchangers because of the following hydrolysis equilibrium which is established in dilute aqueous solutions:

$$Na_2CO_3 + HOH = NaOH + NaHCO_3$$

When sodium carbonate is used as a regenerant, carbon dioxide is liberated by reaction with carbonate and bicarbonate salts with acid.

By the use of a cation and anion exchanger, degasification of the carbon dioxide formed in the reaction of the anion exchanger, and silica removal by ion exchange, a dionized water can be obtained that is equivalent to, or in some cases even better, than distilled water.

CHEMICALS AND TESTS

Dr. Hall of the Hagan Corporation found that sodium hexametaphosphate could be used in the treatment of boiler feed water to reduce scaling and corrosion in boiler tubes in about 1933. Other chemicals have been developed along this line, the most recent of which is a chemical known as versenate. This is tetrasodium tetraacetic ethylenediamine. It is claimed that this chemical does not break down at high temperatures like the polyphosphates do.

Considerable progress has been made in the use of chlorine in water treatment, particularly in the field of taste and odor removal. The application of large doses of chlorine to the raw water is known as break-point chlorination, and oxidizes the organic matter in the water.

One of the problems that has irked water works men is that of sludge disposal from lime-soda treatment plants. We still have the problem here in Columbus. Estabrook and Hoover both developed systems for obtaining the calcium carbonate in a very pure state and then this can be burned to recover lime to reuse. About a year ago, the Miami Florida plant completed an 80 ton per day capacity lime plant. The magnesium content in their water is low and the lime can be reburned a number of times. They expect to supply all the cities in Florida that use lime in their water works.

A few new methods for testing water have been developed in the period covered. One is an electrical instrument known as the solubridge which is essentially a milliohmmeter arrangement with a photo-electric cell. This instrument is calibrated to read directly in grains per gallon total dissolved solids.

An indicator that was developed in 1941 by Stancil Cooper of Washington University of St. Louis, Missouri, is considerably better than methyl orange in the determination of total alkalinity in water. Many of you may have used this indicator which is a mixture of one gram of brom cresol green and 0.2 gram of methyl red in a liter of isopropyl alcohol.

About the best development in the testing field as far as a water works laboratory is concerned is that of the determination of total hardness by the versenate method. The disodium dihydrogen versonate is used in this case. The solution is standardized against a standard calcium chloride solution just as soap solution is. It only takes a few minutes to run this test and is far superior to the old soap solution method and the soda reagent method for non-carbonate hardness.

I believe that I have covered the important developments in the past 15 years and trust that I have stimulated an interest in you in water, the cheapest commodity on earth, costing the consumer about 6c per ton delivered to his tap.

LIFE HISTORY AND RESPIRATION OF THE MILKWEED BUG ONCOPELTUS FASCIATUS (DALLAS)[1]

R. EMERSON NISWANDER[2]
Entomological Laboratories
The Ohio State University

The milkweed bug *Oncopeltus fasciatus* (Dallas) goes through five instars before the adult stage is reached. The incubation period for the eggs is about five days at 76° F. Newly deposited eggs are a light lemon-yellow gradually changing with age to reddish. The red eyes within become distinct as incubation progresses. A short time before hatching a back and forth movement of the eyes can be seen after which the shell membrane at the cephalic end ruptures and the nymph emerges. This movement is the first sign of hatching. The appendages unfold from the cephalic end posteriorly, however, one of the last portions of the nymph to become free of the egg is the proboscis which is long and extends posteriorly between the appendages on the ventral surface.

The abdomen of the nymph is elongate when first hatched but soon becomes more oval and the entire body darkens. The first and second instars are difficult to separate by appearance only. To be positive that the second instar is under observation one should see molting or find the cast skin.

The third instar is easily recognized by the appearance of swellings caused by the metathoracic wing-pads located on the posterior margin of the metathorax.

The fourth instar is recognized by the appearance of swellings caused by the mesothoracic wing-pads located on the posterior margin of the mesothorax.

The fifth instar is considerably larger than other instars. There are lateral spots on all of the abdominal segments and median dorsal spots on the fifth, sixth, seventh, eighth and ninth abdominal segments. These spots are more pronounced than in any other instar. The remainder of the abdomen varies in individuals from yellow to reddish-orange.

The recognition of adult males and females is easy. The female pygidium is triangular in outline and cleft, whereas, that of the male is rounded and shining. In addition, the margins of the abdominal sternites are all straight in the male, whereas in the female the posterior margin of the third abdominal sternite is drawn out backward into a low median point. The female is usually larger than the male.

Mating begins from 5–12 days after emergence, and oviposition 5–15 days after the first copulation. The amount of food available has much to do with the fecundity of the bugs. It was observed that they may survive for a considerable time on limited food but no eggs were produced. It was also observed that virgin females rarely lay eggs. If they did the eggs were infertile.

Longevity of life is variable, the males usually living slightly longer than the females.

LENGTH OF INSTARS

The length of a stadium varies primarily with temperature and food condition. The following table shows the rate of development from egg to adult stage with

[1]A digest of a thesis submitted in partial fulfillment of the requirement for the Ph.D. degree under the supervision of Dr. Ralph H. Davidson, Associate Professor of Entomology, The Ohio State University.

[2]The author now holds the position of Associate Professor of Zoology, Manchester College, North Manchester, Indiana. Acknowledgment is made to the Statistics Laboratory, The Ohio State University, for the analysis of data used in this paper.

the temperature averaging about 76° F. Andre (1934) shows that the incubation period of the eggs varies only three days when temperatures of over 17 degrees difference are used, e.g., at 76.1° F. six days are required for incubation and at 93.2° F., three days. For the longevity of adult life at 76° F. the variation was about four and a half days and for the instars about ten days.

The data in Table I are based upon thirty eggs placed in separate containers and observations made to determine the time of hatching and the length of each stadium. No appreciable difference was observed in the rate of development between males and females. The experiments in this investigation are based on the following table, and no appreciable variation in development was found when the insects were used for testing.

TABLE I

SUMMARY OF LIFE HISTORY IN DAYS AT TEMPERATURE RANGE OF 74°–80°F.

	Egg	Instar					Total Days		
		1st	2nd	3rd	4th	5th	Nymphal Life + Egg	Adult Life	
								Male	Female
Average Days	5	4.32	3.70	3.52	5.47	8.78	30.75	30.4	23.95
Range in Days		4–6	3–5	3–5	4–7	8–10	22–34	27–34*	22–27

*A number of adult males used in testing lived for 35 and 36 days and one lived for 39 days.

METHODS AND MATERIAL

The milkweed bug is reared easily under laboratory conditions. The food used was milkweed seeds. Strips of cellucotton in which the females deposited their eggs were placed with the bugs. The eggs were removed daily so that their age was known. If the eggs were not used for testing they were placed in small containers with a piece of wet cellucotton to prevent desiccation. The nymphs after hatching were placed in plastic refrigerator dishes. By this means insects of known age were available. After a "run," the insects were placed again in the container and used for subsequent testing.

It was found that watermelon seeds could be used in place of milkweed seeds as a source of food supply. The bugs did not feed on the watermelon seeds unless the seed coat was removed or cracked. Seeds were run through a hammer mill with no screens so that they were cracked open but not crushed. The bugs apparently cannot feed on finely ground seeds but most probe the seed with their proboscides. The ground embryo and seed coats need no separation before being used.

The Warburg direct method, using a "Warburg" apparatus, was used for the study of oxygen consumption and carbon dioxide production. The procedure is like the methods described by Dixon (1943) and Umbreit (1949).

RESULTS

It was found that during the first two days of incubation of the eggs there is a low oxygen consumption as compared to the remaining days. This same observation has been made by Melvin (1928) while investigating other insect eggs. He also found that in this early part of incubation, temperature had very little effect on oxygen consumption, so that during early embryonic development there is a

period when metabolic activity is low. Fink (1925) in his investigations found a low period of metabolism which he called the formative period.

If one compares the oxygen consumption with a study of embryology at this time one finds that about eight hours after the egg has been laid (milkweed bug) the cleavage nuclei can be seen migrating toward the periphery of the egg. By the fourteenth hour the nuclei are all in the thin cytoplasm at the surface (Johannsen and Butt 1941). Perhaps this migration would explain the low oxygen consumption; as the nuclei migrate there is less mitotic division and thus a small amount of oxygen utilized.

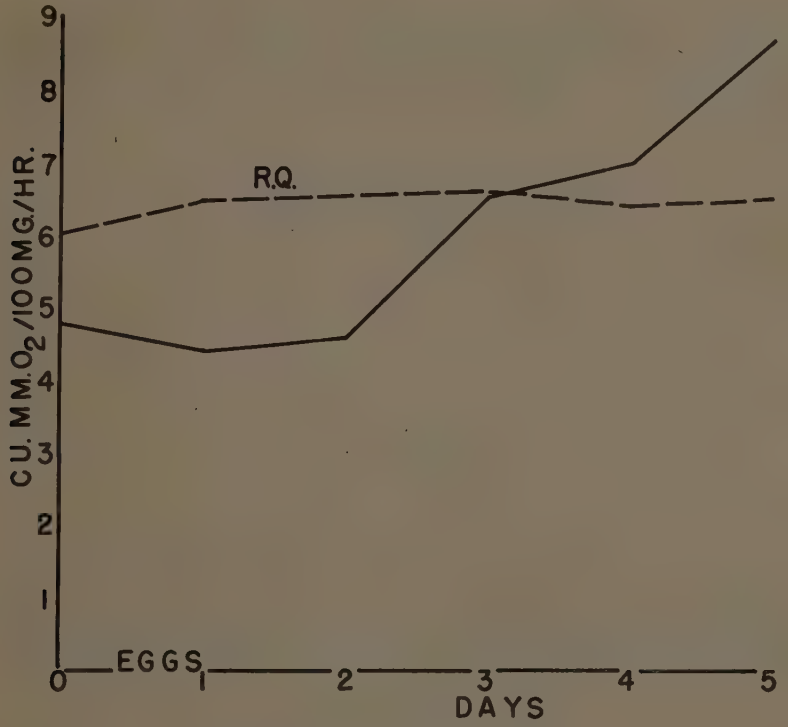

FIG. 1. Cell growth and reproduction may explain the increase in oxygen consumption as shown by this curve.

By the twentieth hour the blastoderm appears thinner on the dorsal side which is the first indication of the differentiation of the serosa from that part of the blastoderm which will form the germ band. This cell growth and reproduction might then explain the increase in oxygen consumption as shown in Fig. 1. With continued mitotic division and organogenesis the oxygen consumption continues to rise and at the time of hatching it has about doubled the amount utilized the day the eggs were laid. Since there is no histolysis taking place at hatching the oxygen consumption is due to the activity of the cells formed. Toward the end of the incubation period there is considerable muscular activity, which can be observed by placing the egg under a binocular and observing the red eye spots

which turn intermittently back and forth. Soon after this is observed the egg hatches. One can probably explain the high rate of oxygen consumption by the movements of the individual plus the greater number of cells which now make up the individual.

The respiratory quotients obtained for the egg are rather low. However, these quotients are not as low as those of other works which have been reported. Fink (1925) found an initial respiratory quotient of 0.521 for *Anasa tristis*. The initial R. Q. observed for the eggs of the milkweed bug was 0.6019, and an R. Q. of 0.6629 the day the eggs hatched.

No completely satisfactory explanation has as yet been brought forward to explain the occurrence of a quotient lower than 0.7, although it is surmised that the substances oxidized are chiefly fats. Fink (1925, cited from Weinland and Bayliss) suggests that oxygen intake is in some way held back in the organism. It can be shown by the increase of weight that oxygen is actually retained. Another

TABLE II

F Values Associated with the Analysis of the Measurements of Oxygen Consumption of the Instars

Instar	2	3	4	5
1	1.72	0.66	1.17	20.12**
2	.....	0.22	5.44*	33.37**
3	.....	.....	3.36	26.57**
4	.....	.....	.....	10.04**

$F_{0.01} = 6.74$
$F_{0.05} = 3.88$
* Significant at 5% level.
** Significant at 1% level.

way in which this phenomenon might be explained is by the conversion of one type of food into another. When a fat is converted to a carbohydrate more atmospheric oxygen is utilized. The fat is relatively low in oxygen while the carbohydrate is high and thus a large amount of oxygen is utilized without production of carbon dioxide. The reverse is also true, when a fat is formed from a carbohydrate, the excess oxygen of the carbohydrate may be utilized instead of atmospheric oxygen. This would cause a high R. Q.

$$\text{R. Q.} = \frac{\text{Volume of } CO_2 \text{ given off}}{\text{Volume of } O_2 \text{ consumed}}.$$

Theoretical equations for this process have been worked out. An example (Richardson 1929 quotes Lusk) for the conversion of glucose into a fatty acid, follows:

$$4C_6H_{12}O_6 + O_2 = C_{16}H_{32}O_2 + 8CO_2 + 8H_2O$$

This assumes the conversion of the whole bulk of the glucose into fatty acid, without wastage, other than carbon dioxide and water. The respiratory quotient of the reaction is 8.0, hence it would require only a little conversion to produce a marked effect on the quotient. If the reverse process, the conversion of fat into carbohydrate occurs, it would be expected to have the opposite effect, namely, a fall in the quotient.

The oxygen consumption reaches the maximum in the first instar and declines with each successive molt (Fig. 2). In a statistical analysis it was found the oxygen consumption of the instars is significantly different from each other at a 1% level. An analysis was then made to compare the means by pairs (the mean value of one instar is the same as another). The results are shown in Table II.

From these data we note that the fifth instar differs significantly in oxygen consumption from all others, the fourth and second differ significantly, the first, second, and third seem to be in the same class.

TABLE III

F Values Associated with the Analysis of the Measurements of Oxygen Consumption (Comparisons Made Day by Day on Eggs and Instars)

Source of Variation	Sum of Squares	Deg. of Freedom	Mean Square	F	Significance
			Eggs		
Days	225.330	5	45.066	18.30**	$1\ F_{0.001} = 3.22$
Error	224.118	91	2.462		
			1st Instar		
Days	363.433	4	90.858	11.49**	$1\ F_{0.001} = 3.72$
Error	395.484	50	7.909		
			2nd Instar		
Days	153.641	4	38.410	5.16**	$1\ F_{0.01} = 3.77$
Error	335.078	45	7.446		
			3rd Instar		
Days	99.779	4	24.944	6.79**	$1\ F_{0.01} = 3.80$
Error	154.235	42	3.672		
			4th Instar		
Days	121.329	5	24.265	9.15**	$1\ F_{0.01} = 3.79$
Error	114.079	43	2.653		
			5th Instar		
Days	165.452	8	20.681	7.34**	$1\ F_{0.01} = 2.77$
Error	194.449	69	2.818		

* Significant at 5% level.
** Significant at 1% level.

In another analysis of data it was found within a particular group (egg or instar) the oxygen consumption differed significantly from one day to another. The following results are in Table III.

In an analysis of the measurements on the zero age group (and the same for other age groups) in Table IV, it was found that the means in the one and three day age group do not differ significantly from each other. Comparing these results

with the table above we can infer that there is less variability within the one day and three day age group than there is among the other age groups of the same instar.

TABLE IV

F Values Associated with the Analysis of the Measurements of Oxygen Consumption (Comparisons Made on the Different Age Groups of Instars)

Source of Variation	Sum of Squares	Deg. of Freedom	Mean Square	F	Significance
		0 Day			
Instar	287.137	4	71.784	10.78**	$1\ F_{0.01} = 3.72$
Error	333.013	50	6.660		
		1st Day			
Instar	65.549	4	16.887	2.20	$5\ F_{0.01} = 2.61$
Error	307.027	40	7.675		
		2nd Day			
Instar	180.183	4	45.045	10.98**	$1\ F_{0.01} = 3.81$
Error	168.145	41	4.101		
		3rd Day			
Instar	37.545	4	9.386	2.17	$5\ F_{0.01} = 2.60$
Error	185.678	43	4.318		
		4th Day			
Instar	220.532	4	55.133	16.18**	$1\ F_{0.01} = 3.86$
Error	129.443	38	3.406		

* Significant at 5% level.
** Significant at 1% level.

In the comparison of the male and female adults for oxygen consumption, results showed that virgin females consumed more oxygen than males. The following are the results of the statistical analysis of the measurements showing this difference:

Mean of Male	Mean of Female	$X_F - X_M$	N_M	N_F	X^2_M	X^2_F
7.648	9.204	+1.556	205	200	13,216.585	18,747.272

$t = 7.072^{**}$ $t_{0.01} = 2.588$

** Significant at 1% level.

A statistical analysis was made on the respiration quotients which showed in general there was no significant difference in all comparisons made, that is, among the instars, between the same age group of the instars and between the males and females. In all probability the respiratory quotient is not as discriminatory a measurement statistically as the oxygen consumption measurement since it is in itself composed of two variables.

Fig. 2 shows the R. Q. beginning with the egg and ending with the adult. The R. Q. starts low in the egg, rises rapidly by the first instar; it then levels off with only a slight rise with the succeeding instars. After reaching the adult stage the R. Q. lowers somewhat and remains fairly constant until death.

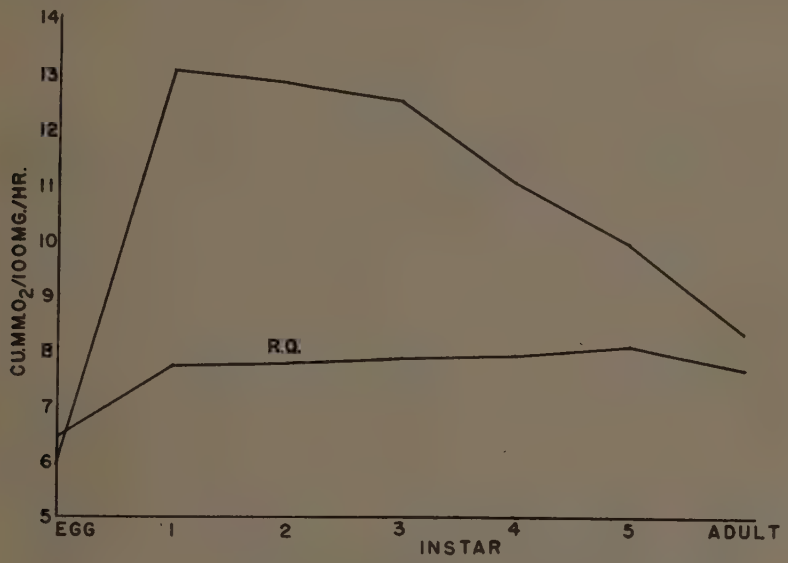

FIG. 2. The oxygen consumption reaches the maximum in the first instar and declines with each successive molt.

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DID YOU KNOW?

Many scientific journals are 6 months to 2 years behind in publishing manuscripts submitted to them. The Ohio Journal of Science is increasing its size in order to afford prompt publication of manuscripts.

NEW CIXIIDAE FROM SOUTHERN NORTH AMERICA WITH NOTES ON OTHERS

(Homoptera: Fulgoroidea)

JOHN S. CALDWELL
Circleville, Ohio

The information conveyed in the article by F. Martin Brown (Ann. Ent. Soc. Amer. 43 : 172, 1950) relating to Federal restrictions placed upon insect collecting in national parks (Field order 768, June 17, 1949, of the National Park Service) comes as somewhat of a surprise to me and I imagine to most of us who do not receive the daily fifty-nine page digest of alterations and additions to Federal laws and regulations. While the reason for such action is very obscure, nevertheless it is an example of the common trend to relegate more authority into fewer hands and to take away the God-given rights and privileges of the individual. Sometimes it seems that the present hub-bub with Russia is a ruse fostered upon the common man while the bureaucrats in this country achieve the same end under the cloak of artificial necessity.

The Cape Sable area and most of southern Florida is about to be completely acquired by the Federal government for a national park to "create refuges for *all* natural life and to preserve particular natural phenomena." It will be unfortunate for science when the process of condemnation crushes the last spark of private ownership in this region and restricts collecting of insects to a favored few, because the Cape Sable region represents the location of an early attempt at tropical agriculture with the probable importation of exotic insects along with exotic plants. Knowing that I shall soon be barred forever from swinging a net in this interesting territory, and partly to satisfy my curiosity of the insect fauna, I recently collected for about one hour on Cape Sable. It is interesting to note that *Haplaxius crudus* (Van D.) originally described from Jamaica and recorded from Cuba was common here and an undescribed *Oliarus* found to be common here also occurs on Vieques (Puerto Rico) and on Antigua (B. W. I.). In addition to these interesting records several new forms were found and are herein described. Incidentally all types are deposited in my collection and are much more available to the public than many others I know of that are "socked" away in so-called scientific or educational institutions.

Haplaxius perrinei n. sp.

Length of male 3.5 mm. General color yellow, greenish beneath. Eyes dark red. Mesonotum slightly golden. Fore wing milky-hyaline with small, black punctations on veins.

Profile rounding. Vertex rounded forward, about three times as long as broad. Forewing more than two and a half times as long as broad; stigma extremely narrow.

Anal segment with a small medioventral projection. Pygofer with lateroposterior margins concave; medioventral process small, acute. Forceps pipe-shaped. Aedeagus with left apical process acute, projected cephalad; right apical process acute, projected dorsad; periandrium lobate apically on left.

Male holotype from Cape Sable, Florida, 2-14-50, (Caldwell).

In general appearance this form resembles *coccis* (Fennah) from Trinidad but the genitalia are different from any species yet described.

Oliarus sablensis n. sp.

Length of male 4 mm. General color black, all carinae light. Median tablet of mesonotum faintly orangish. Forewing milky; veins except costa, black.

Vertex three times as long as broad, deeply trough-like. Intermediate carinae of pronotum

not reaching the posterior margin. Intermediate carinae of mesonotum close to lateral carinae, rather indistinct. Forewing about three times as long as broad.

Male pygofer with lateroposterior margins produced, obtuse; medioventral process acute. Forceps slightly broadened apically, slightly recurved. Aedeagus with terminal segment inflated, terminating in an acute process; periandrium produced into four apical processes.

Male holotype from Cape Sable, Florida, 2–14–50, (Caldwell).

Differing from other oliarids by phallic characters as noted.

Oliarus gladensis n. sp.

Length, male, 4 mm.; female, 5.1 mm. General color black with all carinae light brown. Pronotum grayish. Median tablet of mesonotum and lateral angles orangish-fuscous, more so in female than in male. Forewing milky-hyaline; posterior part of stigma, cross veins, and apical veins black; remainder of veins yellowish with very minute, widely spaced, black punctations.

Vertex almost twice as long as broad; lateral margins greatly elevated; facets very narrow, elongate. Intermediate carinae of pronotum reaching the posterior margin. Intermediate carinae of mesonotum obsolete.

Female valves short, broad. Pygofer of male with lateroposterior margins lobately truncate. Forceps strongly recurved apically. Aedeagus lobate apically, seven acute processes present, one minutely spurred subapically and one pair short and twisted.

Male holotype, female allotype, and paratypes of either sex from Dade County, Florida, along the glades, 3–1–50, (Caldwell).

This form somewhat resembles *chuliotus* Ball but differs by phallic characters as noted in the description.

Oliarus nanatus new name

Several people have called my attention to the fact that *nanus* Cald. (Pan-Pacific Ent. 23: 149, 1947) is a homonym of *nanus* Ivanoff (Liste des Cigales: 110, 1885). Herewith I propose the name *nanatus* for *nanus* Cald.

Oliarus altanatus n. sp.

Length, male, 4.9 mm.; female, 5.5 mm. General color jet black with cranial and pronotal carinae dark orange. Male with median mesonotal carinae faintly orange; female with all mesonotal carinae orange. Forewing yellowish-hyaline, slightly enfumed apically in female; posterior part of stigma, apical cross veins, and apical veins black; remainder brown with black punctations.

Vertex one-third longer than broad. Intermediate pronotal carinae not attaining the posterior margin. Forewing little over two and a half times as long as broad; claval veins united far basad.

Pygofer of male with lateroposterior margins broadly lobate. Forceps greatly expanded apically, clavate. Aedeagus ending in three small processes, the more apical the longer; left portion of periandrium caliper-like with upper and lower "jaws" equally produced.

Male holotype and female allotype from Jacala, Hidalgo, 9–26–41, (DeLong, Good, Caldwell, and Plummer). Paratypes of either sex from Zimipan, Hidalgo, 10–31–45, and Jalapa, Veracruz, (DeLong, Elliott, and Hershberger). Male paratypes from Mexico City, D. F., (Dampf), (DeLong), and one from Davis Mts., Texas, (Martin).

This form slightly resembles *concinnulus* Fowler and *dondonius* Ball in development of the periandrium but differs from these two by chrotic and phallic characters as noted in the description.

Oliarus bazarus n. sp.

Length of male 5.4 mm. Black with light carinae. Mesonotal carinae orange; space between lateral and intermediate carinae orange anteriorly. Forewing milky-hyaline; posterior cross veins black; remainder of veins yellowish with black punctations.

Vertex one-third longer than broad. Intermediate pronotal carinae not attaining the posterior margin. Intermediate mesonotal carinae very close to the lateral carinae anteriorly. Stigma small, triangular.

Male pygofer with lateroposterior margins greatly produced, acute; medioventral process

short, slender. Forceps strongly recurved apically. Anal segment truncate apically. Aedeagus with terminal segment shape of "bottle-opener" in ventral aspect; periandrium with seven major processes.

Male holotype from Cuernavaca, Morelos, (DeLong, Elliott, and Hershberger).

Differing from other oliarids by phallic characters as noted in the description.

A NEW SPECIES OF BIZARRE MEXICAN LEAFHOPPER BELONGING TO THE CICADELLINAE

(Homoptera—Cicadellidae)

DWIGHT M. DeLONG AND ROBERT F. RUPPEL
Department of Zoology and Entomology,
Ohio State University,
Columbus, Ohio

Among the Mexican material belonging to the *Cicadellinae* is a strikingly marked species with interesting structural characters. This we have placed in the genus *Parallaxis*.

Parallaxis jalapai n. sp.

Resembling species of Eupterella superficially, with a long produced flat vertex but with venation more similar to Parallaxis and Empoasca. Length, female, 4 mm.

Vertex flat and produced, not quite as long at middle as basal width between the eyes, apex rounded. Head decidedly narrower than pronotum. Hind wing with a definite marginal vein, forming two closed cells.

Color: White, vertex with a large round black spot just back of apex. Face pale yellow with two parallel, narrow red lines just beneath margin of vertex. The upper one visible from above on the sides of vertex where it touches eyes anteriorly. Pronotum white anterior border tinted with yellow and with three black quadrate spots just posterior to margin. One is at middle and one is posterior to either eye. A reddish blotch is on the median posterior portion of the disc. Scutellum white with a large black spot in each basal angle. Elytra brightly marked on anterior portion, posterior half smoky to black with pale veins. The clavus is crossed by a reddish blotch at the apex of the scutellum. Just posterior to this is a bright yellow area joined posteriorly by a dark brown portion which extends from the middle of the clavus to a white apical area. The costal portion is yellow with a black spot not far from the base. A white spot occurs on the corium surrounded by a brownish area. The claval vein and the sutural vein are reddish. There is a large black spot on the thorax just ventral to the attachment of the first pair of wings.

Genitalia: Female seventh sternite strongly produced and rounded. The posterior margin keeled at middle rather broadly, shallowly notched.

Holotype female and paratype female collected at Jalapa Rd. Vera. (K-241) October 13, 1945, by Shaw, DeLong, Hershberger and Elliott.

This species probably belongs to a separate genus of the Alebrini. This problem we are referring to Mr. D. A. Young who is working on a generic revision of the *Cicadellinae*.

CAN PHILOSOPHICAL ANTHROPOLOGY BE A SCIENCE?
An Examination of Bidney's Philosophy of Culture[1]

VIRGIL HINSHAW, JR.
The Ohio State University
Columbus 10, Ohio

I.

. . . the basic conflict in modern thought is one between diverse metaphysical approaches on the one hand, and anti-metaphysical tendencies on the other. Classical ontological thought attempted to view the phenomena of nature and life *sub specie aeternitatis*, whereas modern ontological thought tends to view cosmic reality *sub specie temporis*. It should not be an impossible task to reconcile these opposite points of view, provided there is agreement on the *possibility* and *necessity* of a comprehensive, ontological theory based on verifiable scientific knowledge, which takes account of the element of structure as well as of process in the explanation of natural and cultural phenomena. But between the classical tradition of the possibility of "substantial" knowledge of reality and the "critical" idealistic position that ontological knowledge is impossible, there can be no logical reconciliation. We must choose decisively between these two contrary positions, if we are to resolve the philosophical crisis of our times. To deplore the intellectual crisis on the one hand, and yet to hold on to the very same anti-metaphysical approach which helped bring it about, as the neo-Kantians and positivists tend to do, is an irrational and hopeless procedure which only serves to make the confusion worse.[2]

It is this most recent claim of David Bidney that I should like, in the present paper, to attempt to refute; but first, to some definitions of terms.

II.

First, I should like to define what I mean by "science" in the question, "Can philosophical anthropology be a science?"

By "science," in this discussion, I want to mean essentially two things: (1) science stresses quantity, not quality; quantification, not qualification. In the words of Galileo, a scientist is one who measures that which is measurable, and makes measurable that which is not measurable. And, (2), science employs an empirical meaning criterion. Let me enlarge on this second characteristic of science.

The statements of science can be classified into two groups: (a) simple and complex factual statements in which all the terms are, directly or indirectly, operationally defined or definable and (b) methodological statements about rules of procedure which scientists must adopt if they are to adhere to an empiricist's criterion of meaning. Thus, I shall speak of the statements of science as being either operational or stipulative. An instance of the first, or operational kind of sentence, is, in physics, $s = \frac{1}{2}gt^2$; and an instance of the stipulative sort is the principle of induction, namely, that the future will resemble the past. Generally, then, this second characteristic of science refers to the much misused term, the scientific method, and to what it properly means. Specifically, I mean by the sciences the physical sciences, the biological sciences and the behavioral sciences. In this scheme, physical anthropology falls most nearly into the area of the

[1]Read before Section K of the Ohio Academy of Science at Granville, Ohio, April 22, 1949, and before the Central States Branch of the American Anthropological Association at Bloomington, Indiana, May 13, 1949.

[2]Bidney, David. "On the philosophical anthropology of Ernst Cassirer and its relation to the history of anthropological thought." *The Philosophy of Ernst Cassirer*. The Library of Living Philosophers, Inc., Evanston, Illinois, 1949, pp. 469–470.

biological sciences, whereas cultural anthropology, as I see it, falls into the area of the behavioral sciences.

Second, I should like to define, negatively, what I mean by philosophy in the present discussion. Philosophy is not science. Although, at times, philosophy makes use of what might loosely be called scientific method, the truth of genuine philosophic propositions is closer to logical validity than it is to factual truth. I am, in effect, distinguishing radically between two levels of analysis. As analytical distinctions, one can distinguish between what I want to call the *scientific level of analysis* and the *philosophic level of analysis*. Though I cannot in this place make clear precisely what I mean by these two levels, it is perhaps sufficient to suggest that they correspond roughly to the definitions of science and philosophy just given.

Finally, it may be noted already from the terms just defined that philosophical anthropology, as I use the term, can never be a science. It is, rather, a genuine philosophic inquiry, properly pursued at the philosophic level of analysis, in the fields of epistemology and metaphysics. To put it more strongly, a good case could be made for arguing that philosophical anthropology is, in a neo-Kantian sense, the whole of philosophy. But this point goes beyond the scope of the present paper.

III.

I now want to turn to an examination of Bidney's position concerning cultural anthropology. In brief, Bidney's position is that science can study the ontological nature of man. "Man has a substantive ontological nature which may be investigated by the methods of natural science as well as a cultural history which may be studied by the methods of social science and by logical analysis."[3] Though already I tend to think that there is, here in Bidney's thought, confusion as to the sort of inquiry science is, since one cannot examine the ontological nature of any object by scientific methods, I should like to support my presentation of Bidney's position with further quotation. ". . . the postulate of an ontological human nature is a prerequisite of both individual and social psychology. The mechanisms involved in inter-individual relations may then be distinguished from the cultural forms in which they are expressed only if one makes this epistemic as well as ontological distinction."[4] ". . . divergent views of culture [idealistic vs. realistic views] may be harmonized if we can conceive culture broadly enough."[5]

In sum, Bidney not only believes that science can investigate man's ontological human nature, but also that the present difficulties in anthropological literature result from a failure to integrate conflicting ontological positions as to that very human nature. Likewise, divergent ontological views of culture, Bidney maintains, may be "harmonized" if we conceive culture broadly enough.

IV.

The case which Bidney builds for his own view has recently been considerably enhanced by his contribution to *The Philosophy of Ernst Cassirer* in the Library of Living Philosophers series. There, he says:

> Thus Kant, in fundamental agreement with Hume, denied the possibility of an ontological knowledge of nature and more than any one else was responsible for the antithesis of science and metaphysics. He did not, however, entirely exclude the notion of a metaphysical or noumenal reality, but maintained that "things-in-themselves" were not the object of scientific knowledge.

[3] "Human nature and the culture process," *American Anthropologist*, 49 (3): 375–399, 1947, p. 396.

[4] *Ibid*, p. 393, footnote 67.

[5] "On the philosophy of culture in the social sciences," *Journal of Philosophy*, 39: 449–457, 1942, p. 451.

In effect this meant that the classic assumption of Greek, medieval, and Renaissance philosophy of an empirically validated ontology was denied. Instead Kant affirmed that "The understanding does not derive its laws (*a priori*) from, but prescribes them to, nature." This meant in sum, that Kant reduced natural philosophy or theoretical science to anthropology.[6]

Later on in his argument, Bidney concludes:

> Thus both the positivists and the neo-Kantian idealists tend to reduce the category of nature to that of culture, thereby turning ontology and epistemology into "culturology" or cultural anthropology.
>
> If one were to adopt a polaristic conception of culture and recognize that the idea of culture is unintelligible apart from its reference to nature, then, it would follow that human nature is logically and genetically prior to culture, since we must postulate human agents with determinate psychobiological powers and impulses capable of initiating the cultural process. In other words, *the determinate nature of man is manifested functionally through cultures but is not reducible to culture.*[7]

Finally, I should like to quote Bidney on his notion of the *metacultural*. For example, at the conclusion of his "Human Nature and the Cultural Process," he says: ". . . *my concern is with the metacultural presuppositions of any system of culture whatsoever*. The problem, it seems to me, was soundly appraised by Dilthey, Ortega y, Gasset, and Cassirer; my disagreement is solely with their Neo-Kantian epistemology."[8]

Again, in the Cassirer contribution, Bidney suggests that ". . . since there is for Cassirer no reality other than cultural or symbolical reality, there can be no meta-cultural or precultural, ontological reality by which to evaluate conflicting standards of value. In the end, we are left with a plurality of empirical ethnocentric, symbolical worlds. . . ."[9]

But now let me turn to an examination of Bidney's points.

First, since Bidney speaks of harmonizing two conflicting ontologies, such as realism and idealism, I feel that another professional philosopher should speak his mind as to the possibilities of harmonizing metaphysical positions. As positivist, I stand accused of reducing the category of nature to that of culture, and thereby turning ontology and epistemology into "culturology" or cultural anthropology. Of this charge, I plead not guilty. Moreover, I should like to press charges against the plaintiff himself, suggesting that, far from having proved his own case, his innocence or guilt hangs upon his own interpretation of historical and contemporary intellectual problems and their methods of resolution.

Specifically, I want to indicate the lines along which one can refute Bidney's conception of philosophy and science, viz., the "classic assumption of Greek, medieval, and Renaissance philosophy of an empirically validated ontology." What does my method of levels do for those dissatisfied with scientists talking philosophy and with philosophers talking science? In the first place, the method suggests that science and the methodology of science are both scientific level enterprises. This means two important things: (1) that science neither presupposes nor implies any genuine metaphysic, and any scientist or philosopher who tries to ascribe a particular metaphysic to science forgets its testable, confirmable, operational character; and (2) that philosophy of science needs neither epistemology nor speculative philosophy to analyze the concepts and methods of science. If epistemological questions arise, philosophy of science retorts with a methodological, rather than an epistemological, answer. The methodological stipulations invoked, with regard (say) to causation, determinism, and the principle

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[6] *Op. cit.*, pp. 485–486.

[7] *Ibid.*, pp. 494–495.

[8] "Human nature and the culture process," p. 396, footnote 75.

[9] *Op. cit.*, p. 543.

of induction, are justified only on pragmatic grounds. No appeal beyond testable experience, or beyond such methodological resolution is ever made.

Why, succinctly, cannot scientists investigate ontological questions? Because they are scientists. If idealism is the ontology actually characterizing this cosmos, this metaphysical fact makes no *scientific* difference. Likewise, if materialistic realism is the ontology of our universe, this metaphysical fact makes no *empirical* difference. Moreover, since idealism and realism are, in some sense, contradictory ontologies, they cannot both be true of one and the same cosmos. So how, possibly, could I, as Bidney tells me, "harmonize" these two genuine metaphysical positions? If I were foolish enough to attempt to keep them both in my philosophy, I would be like any one else who tries to hold on to both propositions of a contradictory pair, namely, I would be insisting upon maintaining a logically inconsistent position. But I cannot develop this point further here.

Second, a word or two more about science and *philosophical* anthropology. Science, as defined earlier, is never more than operational and stipulative in character. Hence, any statement intended as a statement about an ontological tenet will either be stipulative as to a way of proceeding in science, or it will not be among scientific statements. At most, therefore, can *physical* and *cultural* anthropology be sciences. As for philosophical anthropology, construed in Bidney's sense, it can no more be a science than can any other epistemological or metaphysical inquiry. If it is a matter of science *vs.* philosophy, as I suggested when defining my terms; and, if philosophical anthropology is philosophy, not science, then there is no empirical way of establishing any specific point concerning philosophical anthropology. Thus, such a study would be valueless for the sciences of cultural and physical anthropology. If, on the other hand, it is a matter of science *vs.* philosophical anthropology, still there is no way of making a genuine science out of philosophical anthropology.

Oil and water do not mix and cannot be mixed. Likewise, science does not mix and cannot, properly, mix with philosophy. It is only those who, like Bidney, try to put oil on the troubled waters of our age who overlook the fact that the oil neither penetrates the waters nor makes them less troubled. Moreover, the oil does not need the water to be oil, nor does the water need oil to be water. Again, the oil neither presupposes nor requires the water, nor does the water presuppose or require the oil. A certain chemist might try to "harmonize" oil with water, coming forth with a new polaristic theory of the elements. But no matter how hard he might try to argue that the divergent characteristics of oil and water may be harmonized if only we conceive of oil and water broadly enough, most of us would fail to be convinced.

Finally, a word or two about Bidney's meta-cultural or precultural reality concept. In so far as I understand Bidney in both his "Human Nature and the Cultural Process" and his essay on Cassirer, what he means by "meta-cultural or precultural reality" is foreshadowed in the following statement: "There is an important distinction to be made between the ontological conditions of the cultural process and the ontological presuppositions of given systems of culture. . . . *In this paper, my concern is with the meta-cultural presuppositions of any system of culture whatsoever.*"[10] Again, compare his statement (already quoted earlier, but from a later work) that

> There is no pre-cultural human nature from which the variety of cultural forms may be deduced *a priori*, since the cultural process is a spontaneous expression of human nature and is coeval with man's existence. Nevertheless, human nature is logically and genetically prior to culture since we must postulate human agents with psychobiological powers and impulses capable of initiating the cultural process as a means of adjusting to their environment and as a

[10] "Human nature and the culture process," p. 396.

form of symbolic expression. In other words, the determinate nature of man is manifested functionally through culture but is not reducible to culture.[11]

Although a great deal could be said about Bidney's use of the much overworked prefix "meta," I choose here to overlook this point, since I have referred to it in another place.[12] However, what has been said about metaphysics or ontology in general, applies equally well to Bidney's conception of a meta-cultural of pre-cultural reality. If he is thinking of such reality as identifiable with the meta-cultural presuppositions of any system of culture whatsoever, he is either making a stipulation concerning a set of rules of procedure in empirical science, or he is concerned with a genuine philosophic problem. If the former is true, then he is not genuinely engaged in a scientific study of an ontological human nature. If the latter is true, he is functioning solely as philosopher, and it is hard for at least one other philosopher to see how this inquiry is directly relevant to the practicing, scientific anthropologist. With this exception in both cases: philosophy may be propadeutic to science, or may be heuristically valuable to the scientist in his theorizing and discovery. Aside from this, however, the precision machine oil of modern science is in no way enhanced by small or large doses of salt water from the philosophic, mighty deep.

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[11] *Ibid.*, p. 395.

[12] Compare Hinshaw, V., and Spuhler, J. N., "On Some Fallacies derived in David Bidney's Philosophy of Culture," *Central States Bulletin* (American Anthropological Association), 2(2): 12–18, 1948, especially p. 16.

For a more systematic sketch of my conception of *levels of analysis*, compare also "Levels of Analysis," (to appear December, 1950), *Philosophy and Phenomenological Research* 11 (2).

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DIARY OF FIVE CHIMNEY SWIFTS

RALPH W. DEXTER
Department of Biology, Kent State University,
Kent, Ohio

A breeding colony of Chimney Swifts (*Chaetura pelagica* L.) on the campus of Kent State University at Kent, Ohio, has been investigated each year since 1944. The methods of trapping, banding, and observation have been published earlier (Dexter 1950a). A report has also been published on the detailed life history of two individual birds over a period of six years (Dexter 1950b). These papers have stimulated sufficient interest to justify another one at this time, giving the known life history of five other birds selected from the 84 Chimney Swifts which have nested from time to time in the air shafts of three adjacent college buildings. Altogether there are 88 air shafts on the roofs of these buildings, but only 27 have been used for nesting, with an average of 19 occupied with a nesting pair each year. The five individuals selected for this paper represent somewhat different patterns from those already published and from each other, giving a more comprehensive review of mating and nesting behavior in the colony which has been studied over the past seven years. To avoid undue repetition, much of the accumulated data on nesting will be reduced to a minimum or omitted altogether, since that pattern is quite similar for all pairs, but variations or unusual features will be described in detail as will the mating combination for each year.

DIARY OF FIVE SELECTED SWIFTS

1. Chimney Swift no. 42-196913, a male which we shall refer to as no. 13, was banded on June 22, 1944, when it was mated to no. 42-196915 in shaft J1. At that time there were four eggs on the nest which was 12 feet down on the south wall. The following day hatching began. That evening both parents were sitting on the new nestling and three eggs. The next day two more hatched. Two days later the fourth hatched. The adults took turns keeping the nestlings warm and catching flying insects for food. At night one parent sat on the nest and the other clung to the wall beside the nest. In a few days the naked nestlings grew blue pin feathers which later opened out into the characteristic black plumage of the species. On July 8 it was discovered that the nest had fallen from the wall and the four nestlings had dropped 40 feet to the bottom of the shaft. Two survived the crash and clung to the wall at the bottom. In a week's time these climbed up some 26 feet to a point about mid-way in the air shaft where they were still attended by the parents. After July 27 the family left this shaft and scattered.

Beginning with May 14, 1945, a pair of birds was seen regularly in shaft J1. One turned out to be no. 13 returned for another nesting season, but he had a new mate at this time, no. 42-1884485. The former mate went into shaft D1 and spent the season with a pair of birds nesting there, although it cannot be stated with certainty whether no. 15 was the visitor or the functional female, since there were two females in the trio. No. 13 with his new mate started nesting on June 17. The nest, made on the same spot as last year, was completed in six days. The first egg was laid on July 1. Two more were laid, but one was lost on July 8. Eleven days later the eggs had disappeared and the adults abandoned the nest. No explanation can be given for this sudden disappearance of eggs and parent birds. The female was never seen again.

No. 13, however, returned to the campus in early May of 1946, and again took up residence in J1. At first he was found with female no. 42-196924, a nesting

bird in shaft G4 for the past two years and which soon left to continue nesting there for the next three years. For several nights J1 was then left empty, but soon no. 13 returned with another female, no. 42-196931, which had nested for the past two years in N9 and had returned to N9 with her former mate earlier this season. However, a change was made and nest building for this new pairing began on June 4. This was completed in a week's time on the same spot as in the two previous years.

On May 12, 1947, no. 13 with his mate of the previous year, no. 31, were found back again in J1 roosting side by side on the wall. Then for two nights a single bird was in the shaft, but it is not known which individual this was. On May 17 two birds were again found there, but soon a single bird was left there once again. Then for several nights no birds occupied this shaft. On June 3, no. 31 was alone there, but after that date Swifts were not again found in J1. On June 21 an examination was made of all shafts in which Swifts had not been found earlier. It was surprising to learn that no. 13 with his mate had moved into J5, just six feet away in the same block of air shafts, and had nested there. Four eggs were on the nest at that time located 13 feet down on the west wall. The next day a fifth egg was laid. Hatching began July 7; either four or five nestlings were raised.

Birds were first found in J5 in the spring of 1948 on May 13. Three days later nos. 13 and 31 were trapped there. While these former mates returned to their nesting site of the previous year, they did not remain together at first. Both left J5 at once. No. 13 was found alone back in J1 on May 19, but did not remain. The following night he and his mate were together in shaft M7 with an unbanded bird, all three of them spending the night side by side. All then separated. No. 31 was found in L3 with 42-188518 on May 23. No. 13 was alone in J2 on May 26. Very soon, however, nos. 13 and 31 were back together in J5 and another nest was started on June 9 on the same site where the previous nest had been made. It required nine days to complete it. The first egg was seen on June 21. Four were deposited in all, but only three nestlings were raised. They left the nest on July 29 and flew out of the shaft after August 9, only one bird being found in this shaft during the rest of the season. On August 12 no. 13 roosted for the night in shaft E1 with the pair that nested there that season and another bird which was not yet banded. This was the last it was seen in 1948.

A pair of Swifts took up residence in J5 on May 15, 1949. A week later no. 13 and his mate of the past three seasons were trapped there. On occasion the two were separated from each other by a short distance rather than being side by side as mated Swifts are usually found. However, on the first of June this pair started nesting together for the fourth year and in the same place for the third time. In six days the nest was ready, and three days later the first of five eggs was deposited. All five succeeded in producing nestlings. They began leaving the nest and clinging to the wall after July 14. Following the end of July Swifts occasionally roosted in J5 for the rest of the season, but it is not known whether they were the ones raised there or not. Nos. 13 and 31 have not been seen since that time. Both failed to return in 1950.

2. Chimney Swift no. 42-196914, a female we shall call no. 14, was first trapped on June 23, 1944. She was mated with no. 42-196922, which was to remain her mate for another two seasons. The nest, containing three eggs, was placed seven feet down on the south wall of shaft K7 within a recess of a few inches in the wall of the shaft which served to protect the nest. Three nestlings were raised which left by the end of July. The male parent, however, remained alone at intervals as late as August 27. No. 14 was recaptured September 25 from the shaft on Merrill Hall with 43 other birds, including 6 birds which nested on the campus that season, but none of them was with its mate of the year.

In 1945 and 1946 no. 14 returned to mate with no. 22, building a nest in the same place during the first week of June, and producing three nestlings each year.

On May 3, 1947, the pair again returned to K7 but soon separated. No. 22 has not been seen since that date. No. 14 then brought in no. 42-196952 for her new mate and continued to nest in the same place just below the overhanging portion of the wall. Four eggs were laid. One nestling disappeared early in development. On July 24 one nestling was found dead at the bottom of the shaft and another one dead on the nest. Both parents were on the wall of the shaft at the time, but no. 14 remained alone in the shaft that night. The male was found alone in M1 two days later. Two months later, however, both parent birds were together in the nesting shaft for a single night, but remained several inches apart. The nest and dead nestling remaining in it were removed from the wall upon discovery, and both were found to be completely covered with a mass of insect pests.

In 1948 the male left no. 14, eventually going into shaft H5 where he nested successfully for the next three years, with a different female each year. No. 14 returned to K7 where she roosted alone at intervals for some two months, failing to mate during that season. On August 9 she roosted in shaft P3 with 12 other birds; on August 27 she again roosted there with 10 birds. One month later she was once more trapped from P3, this time with 32 other Swifts, flocking in preparation for migration.

In the spring of 1949, no. 14 returned and was found in turn in both M1 and K7 with a new male, which soon disappeared from the campus colony, leaving no. 14 without a mate for that season. She roosted alone until the end of the nesting season, joining other birds at that time. On May 1, 1950, she returned for another year and was found in M7 with the male which had nested there the previous year, but they roosted on opposite walls. Two weeks later she was back in K7 with her former mate of that shaft, no. 52, but he soon returned to H5 for another nesting season. No. 14 then moved back into M7, but the male there had in the meantime brought in another female (42-196906). Nevertheless, all three remained together throughout the nesting season and even for some time after the juveniles left the nest. During incubation one sat on the nest while the other two clung to the wall just below it. Sometimes all three roosted side by side near the nest. Four young were raised. Apparently no. 14 was an all-summer visitor. After the nesting season, no. 14 was found roosting with three other birds in shaft P3 on the roof of the Administration Building in the evening of August 19. When no. 14 was released from the trap its flight was very feeble. It glided to the ground and died several hours later.

3 and 4. Chimney Swifts no. 42-196909, a female, and no. 42-196921, a male, have been so intimately related in their life history that the two will be considered together. They were first found mated in shaft E1 in the summer of 1944 where they had made a nest on the west wall 25 feet down from the top. Three nestlings were produced from four eggs laid. For a brief time a third swift lived with this pair during the early nesting period. After the juveniles left the nest a number of birds roosted with them. On July 24 seven other birds, including one previously banded, were trapped with the parents. Three of these may have been their own offspring. Four days later 10 banded birds and five unbanded birds roosted with the original pair, two of the 15 being repeats from the trapping of four days earlier. On August 5 ten birds roosted in this shaft; but after that, none was found for several weeks. During the latter half of September and the first four days of October, two birds roosted there until they left for the season.

In 1945 no. 21 did not return. However, no. 9 came back to E1 and mated with another male which was one of those that had roosted with the original pair at the end of the preceding year. Four young were raised, but this new mate did not return again. Strangely enough no. 21 came back in 1946 to its former mate after a year's absence and again they nested in E1. They were together in that shaft as late as September 24 although they did not spend every night there in the latter part of the season. In 1947 they nested together for the third time.

Five eggs were deposited of which four hatched. On July 10, several days after hatching, all of the nestlings disappeared. That night one parent roosted under the nest which now contained only the infertile egg while the other parent roosted on the adjoining wall. The next day they deserted E1 and were not seen again for some time. On September 18, no. 21 roosted there with five other Swifts, but not with his mate. On October 4, however, the two mates roosted together in E1 with one of the birds from the small flock found earlier. These were the last Chimney Swifts seen on the roof in 1947.

Both birds returned to E1 in 1948 for another nesting season. This time they were successful in raising four nestlings in a new nest constructed on the site of the old one which they removed from the wall as soon as they returned in the spring. In 1949 they mated together for the last time, again producing four offspring. During that season they had two frequent visitors which roosted with them from time to time throughout the nesting season and during the post-nesting season. On August 11 no. 9 was found dead by a schoolboy, Bobby Bilanych, a quarter of a mile from the Kent campus.

No. 21 returned for at least the seventh season in the spring of 1950. At first there were two birds residing with him, his new mate, no. 42-188595, and another male, no. 42-188588. The latter was one of the all-season visitors of the preceding year while the former was one of the occasional visitors roosting in E1 after the nesting season of 1949 A nest was made at the usual place, and one egg had been laid, when on June 4 it fell from the wall after a rainstorm. In two days time a new nest was under construction on the foundation which remained from the first. Four eggs were laid. At the time the second nest was completed, the visiting male, no. 88, left E1 to enter G3 and mate with the female there whose first mate had fallen dead in the shaft six days before. After the nesting season, however, no. 88 returned to E1 and roosted with no. 21 again.

5. Chimney Swift no. 42-184486, a male, was banded as a juvenile on October 5, 1945. It returned to the campus buildings on the first of May, 1946, with 42-196912 in shaft D1 where the latter bird, a female, had nested for the past two years. One week later no. 86 was retrapped from D1 but this time it was with 42-196934, another male, which had nested in D1 with no. 12 and another female the previous year. On May 17 all three of these, nos. 86, 12, and 34, were together in D1, and remained together for the nesting season. It is not known whether no. 86 or no. 34 was the functional male, but most likely it was the former since the latter was found visiting in another shaft at the time that nest construction was being completed. The nest was made 34.8 feet down on the south wall. After the nesting season, on September 26, no. 12 came back to roost in D1; but she was not with either of the males with whom she nested. Instead, she was hanging to the wall side by side with the other female 42-196915 which had spent the nesting season with her and no. 34 during the previous year. At this time no. 86 was roosting alone in D3.

In late April of 1947 nos. 86 and 12 returned to D1, nesting together without any visitor since no. 34 went to the adjoining roof and nested in S1 where it continued to do so with the same female for another two years. In 1948 nos. 86 and 12 again returned to D1, removed the old nest still hanging on the wall, and prepared a new one on the same site. One night, just as nest construction was getting under way, they were visited by a bird which had been banded from D1 the previous September, but it was never seen again. The pair continued to roost in D1 off and on after nesting was finished for the season until September 27.

In 1949 no. 86 returned to D1 on May 15 with his former mate no. 12 and another male which had roosted with them in D1 the previous year, but which soon left. Nest building began ten days later, and again they built on the south wall 34.8 feet down from the top. During its construction a new bird, a male which was then banded with no. 42-188589, joined the mates and remained for the

balance of the nesting period. Two days later the nest, then about three-fourths made, disappeared. A new one was started immediately on the same foundation. Four eggs were laid, one of which failed to hatch. It is possible that a change of mates may have taken place, the new bird replacing no. 86 as the male parent, but there is no evidence to support such a belief. Furthermore, no. 86 was observed in the process of incubation which he probably would not do if he had been supplanted as a parent. In any case, all three returned to shaft D1 for another nesting on May 8, 1950. A new nest was made at the usual place, and the first egg appeared May 27. Five eggs were laid, but one was lost. After June 4 the eggs were deserted. Three days later no. 86 roosted high in the shaft alone, making no attempt to incubate the eggs. On June 11 the eggs disappeared from the nest. Six days later no. 86 came back with a new female which proceeded immediately to lay eggs in the same nest until a clutch of four was complete. The former female parent, no. 12, disappeared. The visiting male, no. 89, then moved into shaft A1, replacing a male which had nested there for five years, and nested with his mate of the past three years.

SUMMARY

Thus we see that while there is a common pattern of seasonal migration, annual return, selection of nesting site, mating, and nesting, there are a number of interesting variations in the breeding process, especially that of choice of or competition for mates, and of the behavior of individual birds in the colony.

1. Swift 42-196913 nested for three years (1944–46) in air shaft J1 with a different female each year. He continued nesting in J5 with the mate of 1946 for the next three years.
2. Swift 42-196914 nested in air shaft K7 with the same male for three years (1944–46), but acquired a new mate in 1947. She did not nest for the following three years, but in 1950 was an all-season visitor with a nesting pair in M7. She died on August 21, 1950.
3. Swifts 42-196909 and 42-196921 were mates in shaft E1 in 1944 and 1946–49. Another male replaced no. 21 in 1945 when that bird did not return to the campus colony. After the death of no. 9, no. 21 continued nesting in E1 with another female in 1950.
4. Swift 42-184486, after visiting a pair in shaft D1 during 1946, mated with the female of that shaft in 1947 and continued to do so for the next three years, although in 1950 the female disappeared immediately after egg-laying and no. 86 brought in a new female to lay a replacement clutch of eggs.

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A SYSTEMATIC STUDY OF THE MAIN ARTERIES IN THE REGION OF THE HEART—AVES XII

GALLIFORMES, PART 1[1]

FRED H. GLENNY

Department of Zoology and Entomology
The Ohio State University, Columbus, Ohio

In this, as in several previous studies on the main arteries in the neck and thorax of birds, the writer presents the basic ordinal characteristic arrangement-pattern, along with some of the important family and specific variations within the limitations of this study. As has already been noted, specific deviation from the basic ordinal arrangement is generally but slight, although in certain orders of birds, especially the Coraciiformes (11) and Ciconiiformes (16), there may be extreme differences in the family arrangement-patterns. Where two carotid arrangements (1) characterize an order, it may be held that the different families have had different immediate ancestors and express certain of these primitive features while other features of anatomy have undergone developmental convergence, thus showing similar or identical characteristics. On the other hand, it may be held that, despite apparent wide differences in one or more important anatomical features, widely divergent species may have undergone rapid and radical monomorphic evolutionary changes with apparent polymorphic resultants in the form of extant species, all of which stemmed from a single common ancestral group or type. In either case, paramorphic development cannot be overlooked in any consideration of phyletic relations—based on morphological characteristics—since instances of paramorphism are to be noted in various major groups of organisms, and more particularly within a single class of animals and for any single characteristic. Such instances of paramorphic development as are especially notable may be due, in large, to the fundamental nature and structural limitations of protoplasm. There are, no doubt, many basic and primitive characteristics commonly inherent in many different, sometimes widely separated, orders of animals. The more closely related families and orders naturally tend to sharply present more basic and closely associated characteristics.

According to Beddard (1) and Garrod (3), the Galliformes are "bicarotidinae normales." In the former order GALLINAE the Pteroclidae, Tetraonidae, Phasianidae, and Cracidae are "aves bicarotidinae normales," while the Turnicidae and Megapodiidae are reportedly "aves laevo-carotidinae." Wetmore (23) places the Tetraonidae, Phasianidae, Cracidae, and Megapodiidae in the Galliformes, while the Turnicidae are assigned to the Gruiformes and the Pteroclidae are placed in the Columbiformes. Within the limits of the present study, Garrod's observations are substantiated. However, further studies, to include the Cracidae and Megapodiidae are necessary to discern whether or not these families have representatives which are not bicarotidinae normales.

The present study is limited to 10 species of the present order Galliformes. Difficulties encountered in obtaining adequate and satisfactory specimens has been the chief limitation in this study. As a result, this paper is of necessity brief, and conclusions based upon these findings can only be regarded as tentative and subject to change, based upon subsequent and more complete observations.

[1]Contributions from Blue Sea Lake Biological Laboratory, Messines, P. Q.

MATERIALS

The writer is indebted to the Royal Ontario Museum of Zoology, the Chicago Natural History Museum, and the Ohio Cooperative Wildlife Research Unit for materials used in this study. Except for the ring-necked pheasant, common barnyard fowl, and hoatzin, only single specimens were available for study.

Suborder GALLI

Superfamily **Phasianoidea**

Tetraonidae

Bonasa umbellus (L.), Ruffed Grouse

Phasianidae

Phasianus colchicus torquatus Gmelin, Ring-necked Pheasant

Chrysolophus pictus (L.), Golden Pheasant

Catreus wallichii (Hardwicke), Cheer Pheasant

Arborophila brunneopectus henrici (Oustalet)

Crossoptilon mantchuricum (Swinhoe), Brown-eared or Manchurian Pheasant

Gallus gallus domesticus Darwin, Common Barnyard Fowl or Chicken

Pavo cristatus L., White Pea Fowl (Indian)

Meleagrididae

Meleagris gallopavo L., Domestic Turkey

Suborder OPISTHOCOMI

Family **Opisthocomidae**

Opisthocomus hoatzin (P. L. S. Muller), Hoatzin

OBSERVATIONS

The basic ordinal arrangement-pattern of arteries in the neck and thorax of the Galliformes, included in this study, is reasonably characteristic. The aortic root (*1*) arises in the left ventricle and passes diagonally to the right before dividing to form the innominate arteries (*2*). The right systemic arch (*3*) arises from the right innominate artery almost immediately after bifurcation of the aortic root and, after passing dorsally in an arch over the right pulmonary artery, passes posteriorly and diagonally toward the median line as the right radix aortae (*4*) to the dorsal aortae (*5*) where the embryonic left radix aortae persists as the ligamentum aortae (*6*). The ligamentum aortae may maintain its proximal connection with the left pulmonary artery (*8*), or may remain as a white, imperforate cord in the supporting connective tissue with only the distal connection. The right ligamentum botalli (*7*) is present, either completely or in part, and may fuse with the ventral face of the right radix aortae. Anteriorly the

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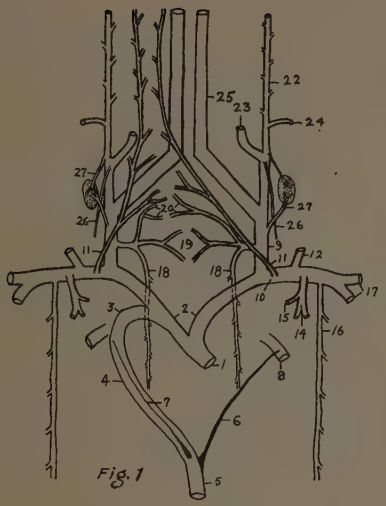
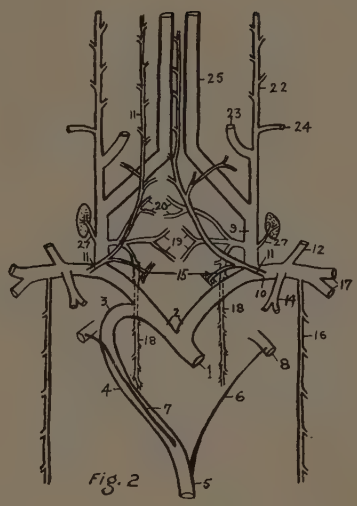
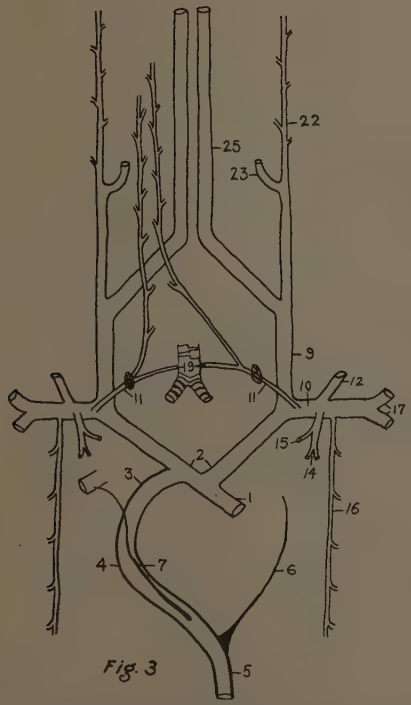
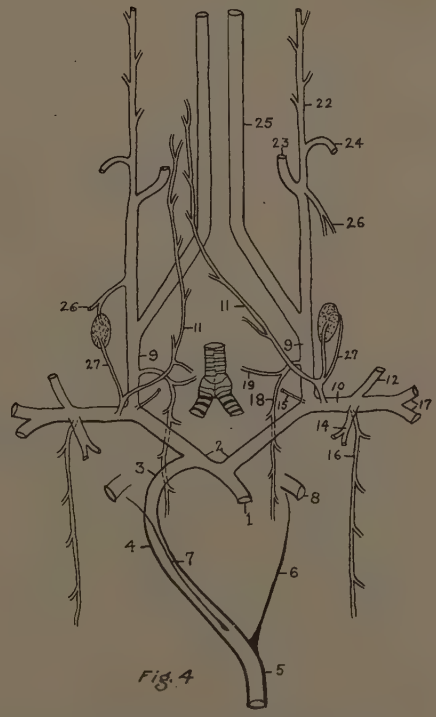
KEY TO NUMBERS USED IN FIGURES

1. aortic root
2. innominate arteries
3. right systemic arch
4. right radix aortae
5. dorsal aortae
6. left ligamentum aortae
7. right ligamentum botalli
8. pulmonary artery
9. common carotid artery
10. subclavian artery
11. arteria ventralis gallinae
12. axillary artery
13. coracoid minor artery
14. coracoid major artery
15. sterno-tracheal artery
16. intercostal artery
17. pectoral arteries
18. ductus shawii
19. syringo-trachael artery
20. meso-oesophageal artery
21. accessory ascending oesophageal artery
22. superficial cervical artery
23. vertebral artery
24. subscapular artery
25. internal carotid (trunk) artery
26. basi-cervical artery
27. thyroid artery
28. arteria pericardia
29. accessory superficial cervical artery
30. basi-oesophageal artery.









Diagrammatic representation of the arteries of the neck and thorax of: (Ventral view).

FIG. 1. *Bonasa umbellus.*
FIG. 2. *Chrysolophus pictus.*
FIG. 3. *Phasianus colchicus torquatus.*
FIG. 4. *Catreus wallichii.*

innominate divides to form the common carotid (*9*) and subclavian (*10*) arteries. The latter then gives rise to the arteria ventralis gallinae (*11*) before giving rise to the axillary (*12*), coracoid major (*14*), intercostal (*16*), and two pectorsal (*17*) arteries. In the Galli, the common carotids give rise to the ductus shawi (*18*) which send off branches to the syrinx and trachea (*19*) and the oesophagus (*20*) before passing posteriorly. The ductus shawi and its branches (*18, 19, 20*) were not observed in either *Phasianus colchicus torquatus* or *Opisthocomus hoatzin*.

In *Bonasa umbellus* (Fig. 1), arteria ventralis gallinae serves as the accessory oesophageal arteries and the vessel of the left side likewise sends branches to the trachea. A short basi-cervical artery (*26*) arises from the superficial cervicals (*22*) near the point of origin of the vertebrals (*23*). The thyroids receive two short arteries (*27*): one from the common carotid and the other from the superficial cervical. The axillary (*12*), coracoid major (*14*), intercostal (*16*), and two pectoral (*17*) arteries arise from the subclavian artery in order. The sterno-tracheal artery (*15*) arises as a branch of the coracoid major.

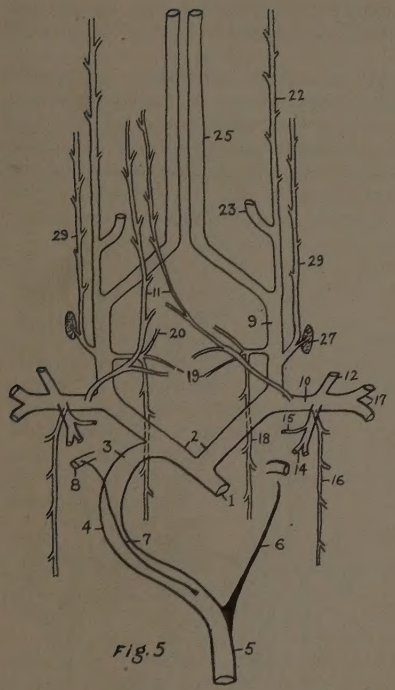
Chrysolophus pictus (Fig. 2). The sterno-tracheal artery (*15*) arises as a branch of the ventral galline artery in contrast to the otherwise normal origin from the coracoid major (*14*); the thyroid artery (*27*) arises as a branch of the common carotid artery (*9*); the ductus shawi (*18*) is present along with proximal branches supplying the syrinx and trachea (*19*) and the oesophagus (*20*) locally.

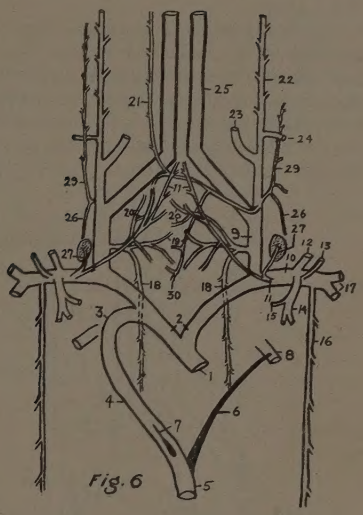
Phasianus colchicus torquatus (Fig. 3): As in the other members of the family Phasianidae, the coracoid major and axillary arteries arise from the subclavian shortly after the origin of the arteria ventralis gallinae (*11*); the intercostals arise just lateral and posterior to the coracoid major; sterno-tracheal muscles are supplied by a branch (*15*) from the coracoid major; the thyroids receive their supply from the arteria ventralis gallinae which then gives rise to a syringo-tracheal branch (*19*) before passing anteriorly to send off branches to the oesophagus and crop. The internal carotid (trunk) artery (*25*) enters the hypapophysial canal to pass anteriorly to the head. The ductus shawi could not be located.

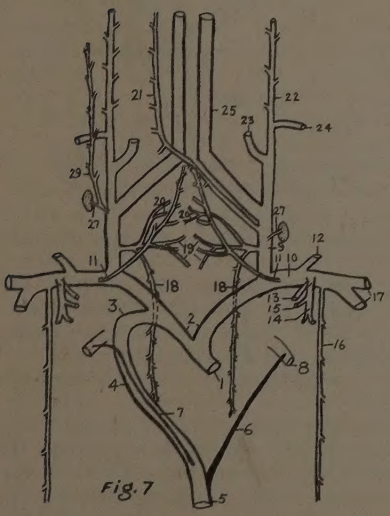
Catreus wallichii (Fig. 4), presents several minor differences in origin of basal cervical vessels: the sterno-tracheal artery arises from the dorso-medial face of the subclavian artery at the base of the common carotid artery; thyroid supply is variable; the left thyroid gland receives two vessels from the arteria ventralis gallinae which then passes diagonally and medially to supply the oesophagus and crop; the right thyroid receives a branch from the right ventral galline artery and another branch from the right basi-cervical (*26*) which sends a branch to the skin and connective tissue near the base of the neck; a notable subscapular artery (*24*) arises from the superficial cervical; the intercostal arises dorsal to the coracoid major from the posterior face of the subclavian.

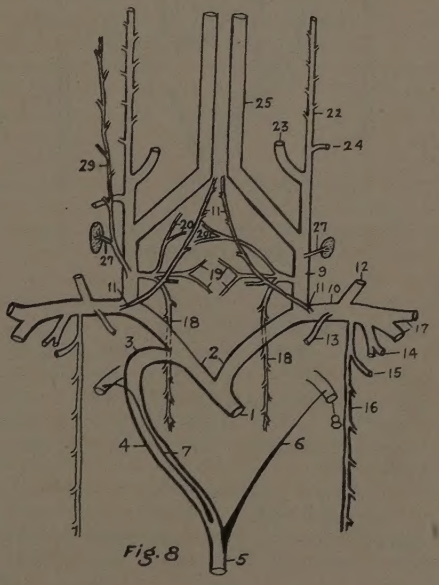
Arborphila brunneopectus henrici (Fig. 5), presents an accessory cervical vessel (*29*) which arises from the common carotid artery and sends off the thyroid artery; the sterno-tracheal artery arises as a branch of the coracoid major. The trachea is medial anteriorly, but about half-way down the neck it passes diagonally to the left and then posteriorly.

Crossoptilon mantchuricum (Fig. 6): Like *Meleagris*, an accessory oesophageal artery arises from the base of the left superficial cervical; as in *Meleagris*, *Phasianus*, and *Catreus*, the thyroid receives a branch from the arteria ventralis gallinae near the latter's point of origin. A short basi-cervical artery arises as a branch of the small accessory superficial cervical artery which arises as a branch of the primary superficial cervicals near the bifurcation of the common carotid; the accessory oesophageal artery (*21*) sends off a basi-oesophageal branch (*30*); a coracoid minor (*13*) arises from the ventral surface of the subclavian just lateral to the coracoid major and axillary arteries and medial to the point of origin of the intercostals. The sterno-tracheal artery arises as a branch of the coracoid major;







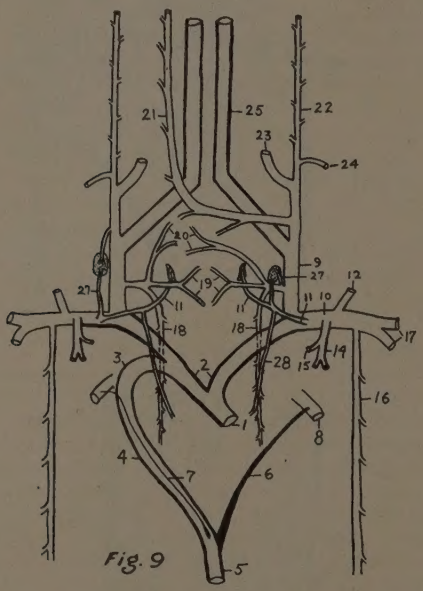


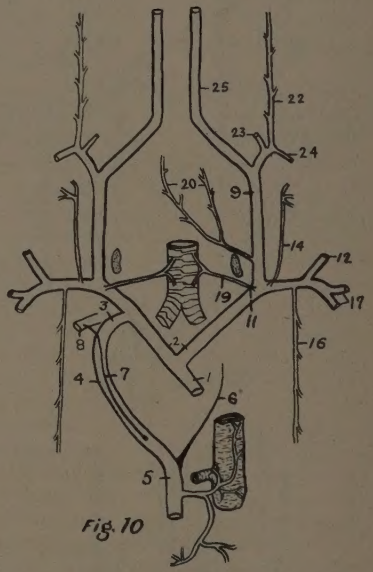
Diagrammatic representation of the arteries of the neck and thorax of: (Ventral view).

FIG. 5. *Arborophila brunneopectus henrici.*
FIG. 6. *Crossoptilon mantchuricum.*
FIG. 7. *Gallus gallus domesticus.*
FIG. 8. *Pavo cristatus.*

the ligamentum aortae is very large and prominent, whereas the ligamentum botalli is reduced to little more than a "button," or is fused in part with the right radix aortae.

Gallus gallus domesticus (Fig. 7), presents a pattern somewhat comparable to that of *Crossoptilon* except that the left accessory cervical artery is absent, and the thyroid receives its supply from a branch of the common carotid; the right accessory superficial cervical is present and sends off a branch to the thyroid of that side; the coracoid minor (*13*) arises from the subclavian near the base of the coracoid major which gives rise to the sterno-tracheal artery as its first branch. Origin of the coracoid minor is in all probability a more variable vessel, with respect





Diagrammatic representation of the arteries of the neck and thorax of: (Ventral view).
FIG. 9. *Meleagris gallopavo.* FIG. 10. *Opisthocomus hoazin.*

to point of origin, than are the other more commonly found vessels, and may not be found in some individuals.

Pavo cristatus (Fig. 8): Very similar to *Gallus* except for minor details: the coracoid minor arises from the subclavian medial to the axillary; the sterno-tracheal arises as a branch of the intercostal which lies medial to the coracoid major and lateral to the axillary. It would appear that *Pavo* is the most atypical of the Phasianidae, thus far studied, in the arrangement of the arteries of the neck and thorax.

Meleagris gallopavo (Fig. 9), varies considerably from members of the Phasianidae, although it follows closely the basic ordinal arrangement-pattern: the accessory oesophageal (*21*) arises as a branch of the left superficial cervical or it may arise from the common carotid near the origin of the superficial cervical; the arteria ventralis gallinae is reduced in function and sends off a branch to the thyroid, and an arteria pericardia (*28*) before supplying the trachea anteriorly; branches of the subclavian are the same as in *Bonasa* except that the coracoid major arises somewhat medial to the axillary. Oesophageal supply of the ventral galline

artery (*11*) was not observed, although it cannot be entirely excluded as a possibility, since these vessels are extremely small, and at times hard to follow unless the vessels are properly injected.

Opisthocomus hoatzin (Fig. 10), presents an arrangement-pattern quite different from that presented by the other gallinaceous birds: the coracoid major arises from the subclavian near the base of the common carotid and passes somewhat more anteriorly to supply the coracoid muscles; the intercostals arise medial to the axillary arteries, and the arteria ventralis gallinae, usually of considerable extent in the other gallinaceous birds, is short and, in so far as could be determined, did not supply the oesophagus and crop; a branch (*20*) from the left common carotid serves as a basal oesophageal supply. No ductus shawi could be found in either specimen which was examined. The cervical branches of the common carotids are the same as in other Galliformes. The ligamentum aortae is much reduced as is the ligamentum botalli.

The coeliaco-mesenteric artery gives rise, in *Opithocomus*, to two main branches, the first of which passes to the posterior end of the proventriculus. The first branch of this vessel recurves around the reduced ventricular valve while the other branch ascends the proventricular wall to the junction with the oesophagus. The second major division of the coeliaco-mesenteric sends off a branch to the liver, and to the gastro-intestinal tract. This latter vessel divides into two branches, the first of which goes to the ventriculus and the other serves as the anterior mesenteric artery.

DISCUSSION

Of the species studied, the most notable feature is the diversity in secondary arrangement of the cervical arteries. Except for the wide deviation from the basic ordinal pattern as found in *Opisthocomus*, the Galliformes included in this study appear to show fairly close relationships in their arterial arrangement-patterns. It would appear, too, that there are at least minor differences in the arterial arrangement within the families of the superfamily PHASIANOIDEA.

Such diversity in arrangement is probably indicative of a long and continuous evolutionary history. It would appear that the several families of this order, though showing certain fundamentally common characteristics, are far from being terminal in nature. This is especially notable in the diversity noted in the Phasianidae which are included in this study.

Whereas uniformity in all major (non-specific) characters is found in some orders of birds which appear to be terminal evolutionary forms, this does not appear to be the case in the gallinaceous birds. In a few orders of birds, the different families do not present uniform ordinal arterial arrangement-patterns. This is notable in the Coraciiformes (11), Colymbiformes (19), Ciconiiformes (4 & 16), and Psittaciformes (1 & 3). Furthermore, in addition to family variations within an order, several large and important families of birds show wide differences in numbers and distribution of the cervical and thoracic supply, as in several families of Passeriformes, Anseriformes (12), Psittaciformes, Ciconiiformes, and to a lesser extent among other orders of birds. On the other hand, there are several families of birds, such as the Picidae (6), Parulidae (Compsothlypidae) (21), Paridae (20), Indicatoridae (6), Phoeniculidae (11), Upupidae (11), Trogonidae (9 & 10), and Coliidae (13), and to a lesser degree in the Rhamphastidae (6), Fringillidae (5), Tinamidae (15), and Spheniscidae (7 & 8), and in members of the Charadriiformes (17 & 18) in which the family patterns are quite uniform with but little or no generic or specific variations of importance. Since in some of the orders there is but one family, the above conclusions may be drawn with respect to the order as well.

Although very few species of this order were examined in the present study, subsequent investigations should further clarify the matter of differences and

similarities within the families and more especially yet within the order. Such additional information may serve as an aid in establishing the natural groups by establishing apparent affinities within the families.

It would appear that the extant members of the Phasianidae, at least, are in a state of divergent evolutionary flux. The Phasianoidea present at least a single pair of vessels (arteria ventralis gallinae) which appear to be singularly characteristic of the Galliformes.

The presence of a large vascular supply to the crop and oesophagus may be correlated with crop-function and the feeding habits of these birds. Increase in size of this structure draws upon or requires increased blood supply.

Greatest differences in the vessels of the neck and thorax are found in the origin of vessels arising from the subclavian artery, and in the origin of the thyroid and sterno-tracheal arteries.

Pavo cristatus, while placed near the end of the Phasianidae, presents an arrangement-pattern which is quite different from the otherwise basic family pattern, and this might be interpreted as indicative of separate evolution, somewhat removed from the central pheasant line of evolutionary development, especially with respect to the organization and supply of the derivatives of the aortic arches and their associated vessels.

Further anatomical evidences to substantiate the position of *Meleagris* are presented by the arterial arrangement-pattern, as contrasted with that of the Phasianidae. In *Meleagris* the coracoid major artery tends to be medial to the axillary artery, while in *Bonasa* it is lateral to the axillary artery, and in the Phasianidae it tends to be opposite to the axillary artery.

The Phasianidae present a problem in grouping due in part to diversity in individual arrangement-patterns, but they tend to show at least close basic and major characters common to the several species studied. It is evident that the Phasianidae do not represent a terminal or end-line group as yet, and may still undergo further important changes in structure before arriving at a point of evolutionary termination.

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